MONTHLY WEATHER REVIEW.

Editor: Prof. CLEVELAND ABBE. Assistant Editor: CLEVELAND ABBE, jr.

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The MONTHLY WEATHER REVIEW summarizes the current manuscript data received from about 3,500 land stations in the United States and about 1,250 ocean vessels; it also gives the general results of the study of daily weather maps based on telegrams or cablegrams from about 200 North American and 40 European, Asiatic, and oceanic stations.

The hearty interest shown by all observers and correspondents is gratefully recognized.

Acknowledgment is also made of the specific cooperation of the following chiefs of independent, local, or governmental services: R. F. Stupart, Esq., Director of the Meteorological Service of the Dominion of Canada; Señor Manuel E. Pastrana, Director of the Central Meteorological and Magnetic Observatory of Mexico; Señor Camilo A. Gonzales, Director-General of Mexican Telegraphs; Capt. S. I. Kimball, General Superintendent of the United States Life-Saving Service; Commandant Francisco S. Chaves, Director of the Meteorological Service of the Azores, Ponta Delgada, St. Michaels, Azores; Dr. W. N. Shaw, Director of the Meteorological Office, London; Maxwell Hall, Esq., Government Meteorologist, Kingston, Jamaica; Rev. L. Gangoiti, Director of the Meteorological Observatory of Belen College, Habana, Cuba; Señor Luis G. y Carbonell, Director, Meteorological Service of Cuba, Habana, Cuba; Rev. José Algué, S. J., Director of the Phillipine Weather Bureau, Manila; Maj. Gen. M. A. Rykachef, Director of the Physical Central Observatory, St. Petersburg, Russia; Carl Ryder, Director, Danish Meteorological Institute, Copenhagen, Denmark.

As far as practicable the time of the seventy-fifth meridian is used in the text of the MONTHLY WEATHER REVIEW.

Barometric pressures, both at land stations and on ocean vessels, whether station pressures or sea-level pressures, are reduced, or assumed to be reduced, to standard gravity, as well as corrected for all instrumental peculiarities, so that they express pressure in the standard international system of measures, namely, by the height of an equivalent column of mercury at 32° Fahrenheit, under the standard force, i. e., apparent gravity at sea-level and latitude 45°.

FORECASTS AND WARNINGS.

By Prof. E. B. GARRIOTT, in charge of Forecast Division.

The movements of barometric areas over the continents of the Northern Hemisphere were more irregular than during the preceding month. Over the Pacific Ocean pressure fluctuations were frequent in the Bering Sea region and the barometer continued comparatively high over the Hawaiian Islands until the close of the month, when readings were slightly below 30.00 inches. Over the Atlantic Ocean pressure was high in northern and low in southern latitudes during the first two decades of the month. This distribution of pressure over the Atlantic gave during the period named prevailing northerly winds over the continental areas that bordered on the middle latitudes of the ocean. On the middle and northern Atlantic coasts of the United States the winds were northeasterly and on the western European coasts they were mostly northwesterly. From the 21st until the close of the month lower pressure in northern and higher pressure over southern latitudes of the Atlantic caused a shift of winds to warmer southerly and westerly over the eastern American and western European coastal regions.

In the United States the month opened with rain in the middle Atlantic and New England States, snow in the upper Lake region and upper Mississippi and Ohio valleys, freezing temperature north of a line traced from the upper Lake region to southeastern New Mexico and killing frosts in the States of the Ohio, upper Mississippi and lower Missouri valleys and the middle and southern Rocky Mountain districts. The morning of the second light to heavy frost was reported in northern portions of the middle and east Gulf States and western portions of the south Atlantic States,and a minimum of 37° was noted at Washington, D. C., the lowest recorded temperature for May at that station being 33° on May 11, 1906. During this cool period in central and eastern districts summer temperature prevailed in the extreme Southwest, with maximum readings 96° at Yuma, Ariz.

The Fort Worth, Tex., Record, of May 5, refers editorially as follows to action taken by Colorado fruit growers to protect their crops from the cold wave of April 30–May 1:

> There was an illustration in Colorado last week of how man's ingenuity combats the elements and sometimes thwarts the full workings of nature. Colorado fruit growers had been warned of the coming of the cold wave which, there was every evidence to believe, would blast the fruit crop. The fruit crop in the threatened Grand Valley is estimated to be worth $3,000,000. Fruit growers immediately got busy with the smudge pot. These oil heaters performed the miracle of heating the whole out of doors. The danger-point to the fruit crop is 28° and the smudge pots pushed the thermometer register up to 32°. The orchards were saved. The cost of equipment was an average of $25 an acre, the cost of running $5 a night, and the estimate is that not more than three nights a year would such precautions be necessary; hence at a cost of $40 there was saved each acre's crop, the value of which runs from $300 to $2,000.

From the 2d to 7th a depression of slight intensity advanced from the north Pacific coast to the Canadian Maritime Provinces, preceded by rapidly rising temperature, attended by showers in middle and northern districts east of the Rocky Mountains and followed by a decided fall in temperature that carried the frost line over the upper Mississippi Valley.

An important disturbance advanced from the middle Plateau to New England from the 7th to 11th, attended by severe local storms in Oklahoma and Missouri on the 8th and in the Ohio Valley and Tennessee on the 9th. The rains attending this disturbance were moderate to heavy in practically all sections from the Mississippi Valley to the Atlantic coast, and a cool wave that followed its passage was attended by freezing temperature in the upper Lake region and northern New England and carried the frost line over the lower Missouri, upper Mississippi and Ohio valleys, Kentucky, and the mountain districts of the south Atlantic States.

From the 10th to 15th, and 14th to 17th, respectively, disturbances advanced from the plateau over the central valleys, and from the southern Rockies to the St. Lawrence Valley. Preceding these disturbances temperature rose rapidly and the highest readings of the present year, 90°, were noted on the 15th in the middle Atlantic States. From the 13th to 15th heavy local rains occurred from the northern Rocky Mountains and middle Plains States over the upper Mississippi and Ohio val-

leys and the southern Lake region and in parts of central and eastern Texas and the middle and west Gulf States. From the 12th to 15th a cool wave advanced from the Plateau over the Rockies, with minimum temperature 23° at Cheyenne, Wyo., the morning of the 14th. This is the lowest temperature on record for Cheyenne for so late a date in May. From the 15th to 17th heavy snow fell at points in the northern Rocky Mountain districts.

From the 18th to the 21st an area of low pressure that moved slowly eastward over the Gulf States and high pressure from the Lake region over the Canadian Maritime Provinces caused cool and unsettled weather generally over the eastern portion of the country, with heavy rains from Texas over the middle and east Gulf States that gradually extended over the south and middle Atlantic States and southern New England. During the 22d and 23d the center of the southern depression moved northeastward near the Atlantic coast attended by northeast gales from North Carolina to Maine.

A disturbance that moved from the middle plateau to the north Atlantic coast from the 22d to 28th was attended by heavy rains east of the Rockies. A severe and widespread barometric disturbance developed over the plateau region on the 27th and advanced over the Plains States and Mississippi Valley during the 28th and 29th, where it remained nearly stationary with a gradual loss of strength until the close of the month. The rain area that attended this storm extended from the middle and north Pacific coast over the middle and northern plateau and Rocky Mountain districts and covered the Plains and Gulf States and central valleys. During the 29-30th severe local storms occurred in the middle and west Gulf States, Oklahoma, and the Missouri Valley and well-defined tornados were reported the night of the 29th in North Dakota and in Brown County, Texas.

BOSTON FORECAST DISTRICT.

[New England.]

Temperature was generally below the seasonal average with much cloudy and unsettled weather and frequent showers. Snow flurries occurred in parts of the three northern States, but the only measurable amount was 5 inches at Jacksonville, Vt. No heavy wind storms occurred. Storm warnings were ordered on the 9th, 21st and 22d. Frost warnings were sent to cranberry growers on the 11th, and temperatures of freezing or below occurred in the cranberry growing sections on the morning of the 12th. There were no storms without warnings, and no frosts in the cranberry regions without warnings.—*J. W. Smith, District Forecaster.*

NEW ORLEANS FORECAST DISTRICT.*

[Louisiana, Texas, Oklahoma, and Arkansas.]

The month opened moderately cool and frosts occurred over the northern portion of the district on a few dates during the first decade, for all of which warnings had been issued. Precipitation was below normal during the first half and above normal during the latter half of the month. Storm warnings were issued for the west Gulf coast on the 5th and 8th. No general storms occurred without warnings.—*I. M. Cline, District Forecaster.*

LOUISVILLE FORECAST DISTRICT.*

[Kentucky and Tennessee.]

Temperature averaged below normal and the first three or four days were decidedly cold. Snow flurries occurred in northern Kentucky on the 1st and 2d. Frost was general over both States on those dates and considerable frost was reported on the morning of the 11th. After the 4th temperature was more seasonable, although there were several cool periods. Rains were frequent and thunderstorms numerous. Precipitation was considerably above normal in western Tennessee and averaged about normal over the rest of the district. Frost warnings were issued for the entire district on the mornings of the 1st and 10th.—*F. J. Walz, District Forecaster.*

CHICAGO FORECAST DISTRICT.*

[Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, and Montana.]

The month opened with strong westerly winds and snow flurries on the upper lakes for which warnings were issued on the last of April. Warnings were again displayed on the 5th in anticipation of a storm that moved from the Rockies directly eastward. Warnings were hoisted on the 15th, 25th, and 30th as storms of considerable intensity approached the Lake region. No casualties of any kind during the month on the upper lakes have been reported, and it is probable that vessel men generally took advantage of the ample warnings given them. A few frost warnings were issued, but as the season was later than usual they were not of much importance.—*H. J. Cox, Prof. and District Forecaster.*

DENVER FORECAST DISTRICT.*

[Wyoming, Colorado, Utah, New Mexico, and Arizona.]

The month was colder than the average throughout the district, and freezing temperatures, for which timely and accurate warnings were issued, visited the agricultural districts. Precipitation was below normal except in northern Utah. The prevailing low temperatures prevented in a marked degree the melting of snow at high altitudes, and the streams rising near the Continental Divide discharged no unusual amounts. The Rio Grande, it is true, was at a high stage, beginning the 10th, as a result of the melting of snow in northwestern New Mexico, but temperatures were too low for the usual flow from the high mountains of southwestern Colorado. Timely warnings were issued for the high stage in the lower Rio Grande.—*F. H. Brandenburg, District Forecaster.*

SAN FRANCISCO FORECAST DISTRICT.†

[California and Nevada.]

The month was abnormally dry, and following an April almost without rain the season has been a remarkably dry one. Unusually heavy and continued rains in January, February, and March indicated a wet season. The snow covering in the mountains at the end of March was one of the deepest ever known; yet notwithstanding moist ground, full streams and deep snow cover there has practically been a cessation of precipitation throughout California since the end of March. There were no warm spells until the close of the month when temperatures exceeded 100° at Redlands, Riverside, Pasadena, San Bernardino, and other points in the San Gabriel valley. In the Sacramento and San Joaquin valleys afternoon temperatures reached 96°. No storm and no frost warnings were issued during the month.—*A. G. McAdie, Prof. and District Forecaster.*

PORTLAND, OREGON, FORECAST DISTRICT.†

[Oregon, Washington, and Idaho.]

The month was cooler than usual and the rainfall though deficient was well distributed. Warnings were issued in time to be of benefit for the only storm of sufficient strength to justify them. Warnings were issued a day ahead for all damaging and widespread frosts. Notwithstanding there was more snow in the mountains at the end of the month than usual the Columbia River did not begin to rise materially until the last two days. Prior to this time the stages in the lower Columbia were the lowest on record for the month of May.—*E. A. Beals, District Forecaster.*

RIVERS AND FLOODS.

Floods occurred during the month in the Allegheny River, the Grand River of Michigan, the Mississippi River between the mouth of the Des Moines River and Hannibal, Mo., the lower Arkansas watershed, central and southeastern Mississippi, western Alabama, the rivers of South Carolina and in the lower Roanoke River. The majority were unimportant,

* Morning forecasts made at district center; night forecasts made at Washington, D. C.

† Morning and night forecasts made at district center.

but those in the lower Arkansas and the rivers of southern Mississippi and western Alabama were very pronounced and destructive, especially in southern Mississippi.

The flood in the lower Arkansas River and tributaries was caused by the heavy rains of May 23 and 24, and flood stages were reached generally on May 25. The crest stage at Fort Smith, Ark., was 26.6 feet on May 27, 4.6 feet above the flood stage; at Little Rock, Ark., 23.5 feet, on May 29, 0.5 foot above flood stage; and at Pine Bluff, Ark., 27.0 feet, on May 30, 2.0 feet above flood stage. The losses amounted to about $300,000, of which two-thirds was in crops, while the value of property saved by the flood warnings was about $60,000. Damage to lands by erosion amounted to about $12,000.

The southern Mississippi and Tombigbee River floods resulted from the excessive rains that began about May 24, and before they subsided in early June some very high stages had been recorded. At Jackson, Miss., on the Pearl River the crest stage was 35.3 feet on May 30, 15.3 feet above the flood stage; at Columbia, Miss., 27.0 feet on June 5, 7.0 feet above the flood stage; at Enterprise, Miss., on the Chichasawhay River, 36.0 feet on May 27, 18.0 feet above flood stage and the highest water of record; at Merrill, Miss., on the Pascagoula River, 25.1 feet on June 4, 5.1 feet above flood stage; at Demopolis, Ala., on the Tombigbee River, 51.1 feet on June 11, 16.1 feet above the flood stage; and at Tuscaloosa, Ala., on the Black Warrior River, 51.6 feet on June 5.

About 70,000 acres of lowlands along the Black Warrior and Tombigbee rivers were inundated, and the losses in Alabama and Mississippi amounted to about $980,000, divided as follows:

Crops	$600,000
Property other than crops	150,000
Damage to farm lands	30,000
Suspension of business	200,000
Total	$980,000

The value of the property saved through the Weather Bureau warnings was about $55,000, a small amount when compared with the losses, but representing nevertheless, all that there was to save at this season of the year.

The losses during the Allegheny River flood on May 1 and 2 amounted to $65,000, and the value of property saved by the Weather Bureau warnings was about $75,000.

The annual rise of the Missouri and Columbia rivers set in during the month, but no flood stages were reported. The Ohio River rise resulted in stages close to the flood stage, and on May 13 passed into the Mississippi River, where the crest stages were also close to the flood stage. At the end of the month the river was still rising at New Orleans, La. The upper Mississippi River was comparatively quiet at stages that are to be expected at this time of the year.

The highest and lowest water, mean stage, and monthly range at 217 river stations are given in Table IV. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Missisipi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

A BALLOON AMONG THUNDERSTORMS.

By Charles J. Glidden. Dated Pittsfield, Mass., May 25, 1909.

Aeronauts in the balloon *Massachusetts* that ascended from Pittsfield on the afternoon of May 24, 1909, had an unusual experience. At an elevation of one mile and thirty minutes after the start, three showers and thunderstorms were noticed, one in the Hoosic Valley, another in the Connecticut, and the third near Worcester. The balloon rose and fell through intervals varying from 1,000 to 10,000 feet, and several times was caught in varying currents which caused the basket to turn and swing from side to side. Under one mile elevation the balloon traveled in advance of one of the storms at a speed of about forty miles an hour, while at an elevation of 10,000 feet calm and sunshine prevailed with the storm rapidly passing below them. Lightning flashes were frequent and heavy peals of thunder shook the basket. After the storms had passed under the balloon a rift in the clouds enabled the aeronauts to drop down into a clearing free from clouds and to make a landing without difficulty. This established the fact that above the storm there existed bright sunshine and no wind.

THE 24-HOUR DAY.

By Chas. A. Mixer, C. E. Dated Rumford Falls, Me., July 17, 1909.

The letter from Mr. Clayton in the March number of the Review, dated June 28 and received to-day, viz, on the adoption of the Kelvin thermometer scale and the metric system, interests me. I wish to approve his recommendation and to add a suggestion intended to complete the recommendation. Really it is a repetition rather than a suggestion, for I have written of it before, but not recently. It is, Adopt the 24-hour time. For seventeen years I have been using the 24-hour day; not alone in my weather records but primarily in all the hydraulic and electric records of our business. It is very easy for even untrained workmen to adopt and use the 24-hour time, and to use it with less error than the 12 hours with A. M. and P. M. With the 24-hour system, "10:40 hr." can mean only one time in the day. It is as easy to write and to think "16-hr." as it is "4 P. M."

Within two weeks I have read in the newspapers that the Russian Government has adopted the 24-hour time. I do not now remember the paper and can name no authority, but I was glad to read of the adoption.

A SIMPLE APPLICATION OF THE THEORY OF PROBABILITIES TO WEATHER PREDICTION.

By C. E. Van Orstrand. Dated Washington, D. C., June 15, 1909.

In the present state of meteorological science, it is recognized that precise predictions of weather conditions for moderate intervals of time are impossible. This imperfection of the science is due to many causes, the most important of which is the uncertainty in both velocity and direction of the approaching storm. Since the forecaster must necessarily take these and other uncertainties into account, it would seem that the most logical method of procedure would be to state the prediction in terms of probabilities in order that the forecaster may more accurately take into account the various factors of the problem; and thus be able to give to the public, in a definite statement, all of the specific information which science is capable of yielding for a particular weather condition; and no more.

This requirement may be met, in a way, by stating the prediction in terms of two scales, each on a basis of 10. On the first scale is represented the probability of the predicted phenomena, and on the second, the estimated amount or intensity. Suppose, for example, that a prediction is to be made on the rainfall in a given area. The maximum rainfall in twenty-four hours is represented by 10 on the second scale of the diagram (Fig. 1); one-half the maximum by 5, and so on to 0, which means no precipitation. On the probability scale, 10 means certainty, probability unity; 5 means an even chance,

and so on to 0, which means that there is not the slightest probability of a rainfall in a given area during a time interval for which the prediction is made. The symbols 8-4 would thus mean that the chances are 8 to 2 in favor of rain and that the total precipitation would be about 0.4 of the maximum. The symbols 2-9 would indicate that the chances are only 2 to 8 in favor of rain and that a heavy precipitation might be expected in case the storm reached the given area. Less accurately, a heavy precipitation with an approach to certainty is indicated when both targets occupy the upper third of the diagram; an average precipitation with about an even chance of its occurrence would be represented by both targets in the middle third; while uncertain weather conditions and light showers would be represented by both targets in the lower third. The left target near the bottom and the right one near the top would indicate a severe storm not far distant, either passing or approaching; while the left target near the top and the right one near the bottom would mean that the probability of light showers is almost unity. The system of nomenclature would not therefore be unintelligible to persons unfamiliar with the theory of probabilities and the ease with which the predictions could be distributed in rural districts by means of the telephone, or exhibited on the streets and elsewhere by means of simple mechanical devices, is suggestive of its usefulness in these respects. Furthermore, the publication of the numbers with the usual forecasts would give additional and precise information not easily expressed in a few words.

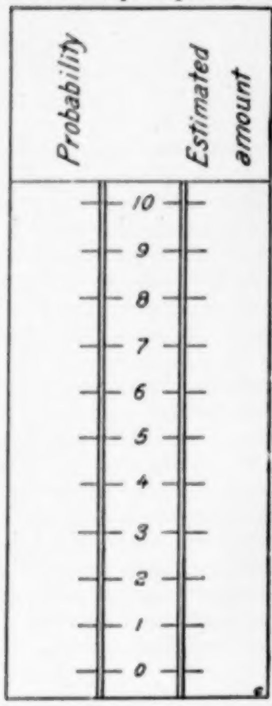


FIG. 1.—Forecast scale, Van Orstrand.

For the most part, the first column may be said to represent the forecaster's estimate of the storm's rate of approach, or, in general, it is the weight which he assigns to the predicted phenomena; and the second column is his estimate of the magnitude or intensity of the predicted phenomena, such as amount of rainfall, temperature conditions, wind velocity, percentage cloudiness, etc. Were meteorology an exact science, the first column, or number, would not be needed, and the numbers in the second column could be foretold to a fair degree of precision for comparatively long intervals of time. Until this stage in the development of the science of meteorology is reached, the more nearly the predictions can be stated in terms of probabilities, the more nearly will meteorologists be able to interpret the various weather conditions, for the benefit of the public, in strict accordance with scientific principles.

COMMENT BY PROF. H. C. FRANKENFIELD.

Doctor Van Orstrand's scheme is very similar to, although somewhat more elaborate than that devised and put into operation in 1905 by W. Ernest Cooke, Esq., Government Astronomer for Western Australia. That scheme was commented on by Prof. E. B. Garriott.[1]

In my opinion both schemes are defective in that while aiming to avoid positive statements (as a rule) in weather forecasts, they fall into exactly the difficulty they are attempting to avoid. There are but three possibilities on the weather chart, as follows:

1. There will be precipitation within a given period.
2. There will not be precipitation within a given period.
3. It is doubtful whether or not there will be precipitation within a given period.

In the present state of our meteorological knowledge any elaboration of these three possibilities will tend only to confuse the situation, and to necessitate attempts at precision beyond the ability of the forecaster with the material at hand. If there is doubt in his mind, it is useless to attempt to qualify it.

The second proposition of Doctor Van Orstrand relative to forecasts of the intensity or quantity of precipitation is open to still greater objections. Logical forecasts of the quantity of precipitation are absolutely impossible, except with two types of storms. In one of these two types the depression moves down the western slope of the Rocky Mountains into western Texas, and then recurves northeastward through the Ohio Valley. In the other type the depression moves from the Pacific Ocean through Mexico into Texas, and thence northeastward. Both these types are attended by heavy rains or snows about 95 per cent of the time. From all other storm types the quantity of precipitation will vary from practically nothing to a number of inches. The solution of the problem depends upon a knowledge of conditions that are not now apparent on the weather chart, and some of this knowledge, at least, we have well-founded hopes of obtaining in the future through a systematic investigation and discussion of the phenomena of the upper atmosphere.

A METHOD OF ADVERTISING CLIMATE.

By FORD A. CARPENTER, Local Forecaster. Dated San Diego, Cal., May 8, 1909.

It is difficult to advertise a climate properly, for statistical tables, columns of figures and weather charts may be ever so carefully compiled and attractively labelled, but the general public balk at tables and charts. The Board of Supervisors of the county of San Diego, Cal., provided the necessary funds to prepare an attractive and practical method of showing features of the climate of San Diego at the Alaska-Yukon-Pacific Exposition at Seattle, Wash.

The San Diego climatic exhibit consists of three pieces of apparatus. To show the cool summers and the warm winters of San Diego an electric-flasher-board has been designed. This consists of a sign 7 feet high and 8 feet long, having vertical lines and horizontal divisions showing the months of the year, and temperatures from 30° to 90°. A row of red electric lights outlines the maximum temperature for every month of the year, and a row of blue electric lights the minimum temperature for the corresponding period. Beginning with January, the red lights burn consecutively, two lights foreach month until the whole year's monthly maximum temperatures are displayed. The illuminated trace requires about 10 seconds to traverse the 12 months. These lights then disappear, and a line of blue lights is begun on the minimum portion of the board. When the line of blue lights is complete, showing the lowest point the thermometer touched in each month, the red and the blue lines are exhibited simultaneously for 10 seconds. Immediately afterwards the red line of lights again begins its trace over the sign, and is again followed by the blue line, and so on as long as the current flows.

To show the current daily maximum temperature in San Diego during the summer of the exposition, there is a representation of a thermometer 7 feet high. Red lights serve to make each 10-degrees point on its scale, and a movable hand, studded with small white lamps, points to the highest temperature at San Diego for the preceding day as officially reported by the local Weather Bureau office at Seattle.

The third piece shows the cool summers and the warm winters of San Diego. The countries of the earth are outlined in color on the inside of a ground glass globe 24 inches in diameter and illuminated by a lamp at its center. On the surface of the globe red and blue lines show the July and January positions respectively of the 50°, 60°, and 70° isotherms for the whole

[1] Monthly Weather Review, January, 1906, 34:23-24.

northern Hemisphere. While most of the countries are labelled, there appears the name of but one city, that of San Diego. The globe is made to revolve slowly by a motor concealed in the base of the supporting cabinet. A careful study of this brilliantly illuminated globe shows the relation of San Diego's climate to that of other parts of the earth. The spectator sees at once that the courses of the summer isotherms between which San Diego lies, also enclose Alaska and Siberia, while the winter courses in blue embrace San Diego as well as portions of Arabia and Egypt.

It would seem practicable to apply some of these methods of attracting attention to more serious purposes than advertising. This would appear to be especially true of the illuminated and revolving globe. The boundaries of the countries of the world, the seas, islands and their designations are painted[1] on the inside of the globe. Such a method allows complete isothermal and other lines as well as the distribution of winds and rainfall to be drawn in water colors on the outside of the glass. Such drawings could be easily erased or changed.

That the general public are interested and study such a climatic display was shown by the results of the preliminary display made in one of the prominent store windows before shipment to Seattle. Several thousand people saw this exhibit during the three days it was shown at San Diego.

[1]A neater and perhaps more satisfactory device for showing geographical boundaries, seas, etc., is suggested by the advertisement of one of the great steamship companies. In this case the excellent projection and map of the D. Riemer globe is glued to the outside (better *inside*) of an almost perfect globe of the proper dimensions, which is illuminated from within and revolved by motor.—*C. A., jr.*

TORNADO AT SAVANNAH, GA.

By H. B. Boyer, Local Forecaster. Dated Savannah, Ga., May 31, 1909.

The most notable feature of the month's weather at Savannah, Ga., was a tornado that struck the city May 1, and swept over the southern and eastern portions. The path was nearly northeast and plainly marked by wrecked buildings, uprooted trees and débris along its entire course through the city. The tornado struck the city at about 11 a. m. and its time of passage across the city was less than two minutes. Its approach was so sudden that people in its path were given absolutely no warning, and before they were aware of what had happened the storm was out of sight.

The tornado followed immediately after an unusually heavy rainfall with severe lightning, and must have originated near the southern limits of the city, as no report of its existence has been received from the surrounding country and no débris was observed in the rotating cloud as it approached the city. An eye-witness describes the cloud as intensely blue-black when first observed, at an elevation of about 400 feet, and not rotating visibly. As it approached the city the cloud lowered and its counter-clockwise rotation became plainly visible. At the point of first damage the tip of the funnel was about 5 feet above the roofs of the Savannah Lumber Company, which sustained some slight damage. From here it lowered until 100 yards farther on its full force struck and wrecked a 4-storied concrete building, entirely removing the top floor. After this witnesses state that the whirling cloud rotated counter-clockwise, was filled with wreckage and intensely black. An apartment house which was destroyed seems to have been exploded. Near Kehoe's Iron Works the cloud passed over a shed opening a hole 6 feet in diameter through the roof very much as though a large cannon had been fired upward through it. After leaving the city the cloud was visible for probably 30 seconds, when all traces of it were lost and no reports of it were received from anywhere in this vicinity.

In an open place near the point of greatest severity of the storm the débris was arranged spirally about the center of the path, the greater portion being on the right side. The greater amount of damage seems also to have occurred on the right-hand side of the advancing storm. The width of the path of maximum destruction was about 200 yards and the longest stretch over which the point of the funnel was in contact with the ground was about 1,500 feet. A block of concrete, weighing about 300 pounds, was carried 3,000 feet. One death, due to injuries received, resulted from this tornado.

The tornado was preceded by severe lightning. Except for a slight oscillation recorded by the barograph and the excessive rainfall, the station instruments gave no indications of a severe storm, and the first news of it reached us by telephone.

METEOROLOGY AT COLBY COLLEGE.

By Prof. H. E. Simpson, University of North Dakota. Dated Waterville, Me., April 9, 1909.

Meteorology has been given as a specific course in the curriculum of Colby College for four years. Previous to this the study of the atmosphere held a relatively large place in a general course in physical geography since the introduction of this subject in 1891. The course occupies one semester and is open to sophomores and juniors, from twenty to forty of whom elect it each year.

The work consists of lectures, recitations and laboratory exercises. The lectures are generally informal and are combined with recitation and class discussion, Davis's Elementary Meteorology serving as a text. Other texts, especially those of Waldo and Russell and the reports of the United States Weather Bureau, are freely used for reference. The class exercises are frequently illustrated with the lantern, for which the collection of photographs, charts, graphs and maps prepared by the Geographic Society of Chicago[1] has been found most helpful. A few slides are used to illustrate almost every lecture and recitation. Occasionally, as in the study of clouds, a large number of photographic slides are used in a single hour.

One 2-hour period per week is devoted to practical laboratory work. This includes non-instrumental weather observations, observations by means of standard meteorological instruments and the correction of observed readings, the construction of weather charts and maps, and weather forecasting. The instrumental equipment includes the complete equipment for cooperative observers of the United States Weather Bureau, together with the barometer, the hygrometer, psychrometer, etc. No attempt is made to secure standard observations for continuous record, since a regular cooperative station of the United States Weather Bureau is located at the Hollingsworth and Whitney Paper Mills on the opposite side of the Kennebec River at Winslow, Me.

In the laboratory as well as in the classroom the lantern is a most valuable aid, especially in the study of type series of weather maps and in forecasting. A few illustrations of our method may be of interest. In the study of the progression of low-pressure areas across the United States, instead of each student working on a separate and indifferent series of original weather maps, a group of slides or even a single "quad" slide, showing a selected series, is used. From these each student may note at once the various changes from day to day and record the essential features on a blank map previously given out by the instructor, and draw his individual conclusions and express them, in writing or orally, as desired. By this method less time is taken, less explanation is required, less confusion is made, and better results are obtained than by the old method.

In forecasting, an excellent exercise consists in basing predictions on one map shown on the screen and then verifying the predictions by showing the actual weather conditions of the day following. The changes of the last twenty-four hours and the conditions shown may then be used to forecast the weather for the next day, and so on for an entire week.

The study of the veering and backing of the winds caused by the passage of a cyclone may be exhibited in a very real-

[1] See J. P. Goode: The use of the lantern in teaching meteorology. Monthly Weather Review, June, 1906, 34:263.

istic way by indicating the position of an imaginary observer by a colored bit of paper placed on the screen to the east of the diagramic cyclone and by moving the lantern in such a way that the storm center passes to the north, to the south, or directly over the observer.

A week of tri-daily non-instrumental weather observations opens the course in order to interest the student and to early cultivate the habit of observation of the weather changes that are daily and even hourly occurring. This is followed by a systematic study and construction of weather maps, step by step, through temperature, pressure, "wind and weather," as these subjects are taken up in class. Each element is worked out in a series of type maps. The elements are then correlated and their progression traced through a series of the maps of the Weather Bureau, so that when the subject of weather maps is reached in class it is simply reviewed, with emphasis on their practical and economic value. The forecasting of the weather from the maps leads to forecasting the current weather from personal observations. In this, the sons of those who "follow the sea" frequently combine experience with science and produce excellent forecasts. In connection with this later laboratory work lectures are given on "The Work of the Weather Bureau," and the course is concluded with a brief summary of the relations of weather and climate to human life.

It will be seen that the course as thus presented is for the general rather than for the special student, and as such offers an opportunity for combined scientific study and observation with most practical application to daily life.

A CHRONOLOGICAL OUTLINE OF THE HISTORY OF METEOROLOGY IN THE UNITED STATES OF NORTH AMERICA.

[*Concluded from the Monthly Weather Review, April, 1909.*]

1882. July. Three U. S. Signal Service men, Park Morrill, A. G. McAdie, and A. L. McRae, were assigned to study and observe atmospheric electricity under Professors Rowland in Baltimore, Md., and Trowbridge in Cambridge, Mass. This marked the inauguration of regular observations in this line of work at Johns Hopkins and Harvard universities. The general report on the subject was made by Prof. T. C. Mendenhall in 1887.

1882. August 10. Prof. William Ferrel was appointed assistant in the office of the Chief Signal Officer. He resigned on his seventieth birthday, September 3, 1886.

1882, 1885, 1887. A series of lectures by professors of meteorology at the Signal Service School at Fort Myer, Va., and subsequently at the Signal Office at Washington, D. C.

1883. Organization of the New England Meteorological Society, which continued in existence until April, 1896.

1883. Prof. Frank Waldo was sent to Europe to make a series of international comparisons between the standard barometers of the respective bureaus and those of the International Bureau of Standards at Paris, in order to secure international homogeneity in barometric work.

1884. Prof. H. A. Hazen took up the systematic study of thunderstorms.

1884. October. By cooperation with the U. S. Geological Survey the Signal Service undertook observations of earthquake phenomena, and a joint committee on seismology was appointed.

1884–1896. The American Meteorological Journal was started by Prof. M. W. Harrington in May, 1884, and continued under his editorship until 1891. Ginn & Company (R. DeC. Ward, editor) carried the Journal from 1891 to the end of the twelfth volume, when in 1896 publication was suspended.

1885. January 1. Prof. T. C. Mendenhall appointed assistant in the Office of the Chief Signal Officer, and assigned in charge of the Instrument Division. He resigned on October 30, 1886.

1885. June. Alexander G. McAdie makes quantitative studies in atmospheric electricity by means of kites at Blue Hill Observatory, Mass.

1885–1886. Profs. C. F. Marvin and H. A. Hazen compared the sling psychrometer with the dew-point apparatus at Washington, Colorado Springs, and Pikes Peak. The results were worked up by Prof. W. Ferrel and embodied in his tables for use with the whirled psychrometer.

1886. The Smithsonian Institution published "Recent Advances in Meteorology" by Wm. Ferrel.

1886. February. The first general Conference of Directors of State Weather Services was held at Washington, D. C.

1887. January 16. Gen. W. B. Hazen was succeeded by Gen. A. W. Greely (*b.* March 27, 1844) as Chief Signal Officer.

1887. All marine meteorological work under the supervision of the Signal Service was transferred to the Hydrographic Office of the U. S. Navy Department.

1887. May. The Weather Crop Bulletin, a revival of the Weekly Chronicle and the Farmers' Bulletin, began and was continued until 1906, when the title was changed to the National Weather Bulletin.

1888. The Signal Service published "Meteorological Apparatus and Methods," by Prof. C. Abbe.

1888. The system of ter-daily simultaneous weather charts changed to a system of semi-daily charts at 8 a. m. and 8 p. m., seventy-fifth meridian time.

1888. The Richard thermograph and barograph and a simple self-recording rain gage began to be introduced at the Weather Service stations.

1888. The cold-wave flag and many other signal devices were introduced, all of which were eventually reduced to a simple system of flag signals now called "Weather Flags."

1889. March. The necessary changes in the Ferguson house, prior to its occupation by the Weather Bureau, were completed on March 5 and on March 22 of this year the Washington station of the Weather Bureau was removed from its former quarters at 1709 G street NW. to the new permanent home on Twenty-fourth and M streets NW. Other divisions of the Bureau moved over at various dates.

1889. Prof. Cleveland Abbe devised, constructed, and distributed copies of his marine nephoscope as used by him on the *U. S. S. Pensacola*, 1889–1890.

1889, September, to 1890, May. The U. S. Scientific Expedition to the West Coast of Africa," otherwise called the *U. S. S. Pensacola* Eclipse Expedition, was conducted under the charge of Prof. David B. Todd of Amherst. Prof. C. Abbe was detailed as meteorologist. The expedition returned to the United States in May, 1890.

1889. September. Ferrel published his "Popular Treatise on the Winds."

1890. In this year "local forecasts" were begun at St. Paul, Minn. (Lieutenant Woodruff), and at San Francisco (Lieutenants Maxfield and Finley).

1890. October 1. The act transferring the meteorological work of the Signal Service to the Weather Bureau of the Department of Agriculture was enacted. This act went into effect July 1, 1891, and defined the scope and work of the Weather Bureau as follows:

> The Chief of the Weather Bureau shall have charge of the forecasting of the weather; the issue of storm warnings; the display of weather and flood signals for the benefit of agriculture, commerce, and navigation; the gaging and reporting of rivers; the maintenance and operation of seacoast telegraph lines and the collection and transmission of marine intelligence for the benefit of commerce and navigation; the reporting of temperature and rainfall conditions for the cotton interests; the display of frost and cold-wave signals; the distribution of meteorological information in the interests of agriculture and commerce, and the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States, or as are essential for the proper execution of the foregoing duties.

1891. July 1. At noon the Weather Service, its buildings,

telegraph lines, stations, apparatus, and men were transferred to the Department of Agriculture. On this date also Prof. Mark W. Harrington (*b.* 1848) was appointed Chief of the Weather Bureau of the Department of Agriculture.

1891. The Weather Bureau published "A General Summary of International Observations" as its Bulletin "A."

1891. The Smithsonian Institution published "The Mechanics of the Earth's Atmosphere," a collection of translations by Prof. Cleveland Abbe.

1892. A special service for the Lake region was established to include studies of the lake currents and to publish a semi-annual Lake Chart.

1892. August. The Second General Conference of the Directors of State Weather Services was held at Rochester, N. Y., in connection with the Association of American Agriculturists.

1892. The Division of Climatology and Hygiene of the Weather Bureau was established, with Dr. W. F. R. Phillips, Climatologist, in charge.

1893. Report of the "Committee of Ten" of the National Educational Association "On the Teaching of Meteorology in the Schools."

1893. Publication of Dr. Frank Waldo's "Modern Meteorology."

1893. August. Meeting of the International Meteorological Congress at Chicago, Ill. Some of the papers presented at this Congress have been published as Bulletin 11 of the U. S. Weather Bureau, while others still await publication.

1893. August 21. The Third Conference of Directors of State Weather Services was held at Chicago, in connection with the International Meteorological Congress.

1893. August. The International Congress on Aeronautics met at Chicago. At this Congress several memoirs on the use of balloons and kites in meteorological research were read; and at this date Professor Harrington ordered the development of the Hargrave kite and other work along these lines by the Weather Bureau.

1893. Extensions of the River and Flood Service of the Weather Bureau were made in this year and in 1899 and 1904.

1893. August. A permanent editor, Prof. Cleveland Abbe, appointed to the Monthly Weather Review.

1894. Publication of Prof. W. M. Davis' "Elementary Meteorology."

1894. Establishment of a district forecast center at Chicago, Ill., with Prof. Willis L. Moore in charge. District forecast centers were subsequently established at Boston, New Orleans, Louisville, Denver, San Francisco, and Portland, Oreg.

1894. August 4. Mr. Eddy flew kites with thermograph at Blue Hill, Mass., Observatory, and kite work begins to develop rapidly at that place by S. P. Fergusson and H. H. Clayton, under A. L. Rotch, Director of the Observatory.

1894. August 17. The Third Annual Meeting of the American Association of State Weather Services was held at Brooklyn, N. Y., in conjunction with the meeting of the American Association for the Advancement of Science.

1895. July 1. The President of the United States appointed Prof. Willis L. Moore (*b.* January 18, 1856) to succeed Prof. M. W. Harrington as Chief of the Weather Bureau.

1895. October 16–17. The Fourth Annual Meeting of the Association of State Weather Services, held at Indianapolis, Ind.

1896. Suspension of the work of the New England Meteorological Society, which was organized in 1882.

1896–97. The international "Cloud Year" for simultaneous observations of clouds. The Weather Bureau cooperated by observing at a number of stations.

1897. Weather Bureau Bulletin "E," "Floods of the Mississippi River," by Park Morrill, was published.

1897. Establishment of a telegraph cable from Galveston to Mexican ports, and of three Weather Bureau stations at the Mexican cable stations.

1898. October 13–14. The First General Weather Bureau Convention met at Omaha, Nebr. [Succeeding the American Association of State Weather Services.]

1899. Publication of R. DeC. Ward's "Practical Exercises in Elementary Meteorology."

1900. January. Prof. Reginald A. Fessenden was appointed as expert in, and the Weather Bureau took up the development of wireless telegraphy.

1900. October. The Weather Bureau published the results of the "International Cloud Year" observations in the United States as prepared by Prof. F. H. Bigelow and others.

1900. November 1–3. First National Meteorological Congress of Mexico.

1900. December. Daily weather telegrams from Europe, were added to the morning daily weather map of the U. S. Weather Bureau; reports from Asiatic observatories were added later.

1901. August 27–29. The Second General Weather Bureau Convention met at Milwaukee, Wis.

1901. Publication of R. DeC. Ward's translation of Hann's "Climatology," Volume I.

1902. The Weather Bureau published "The Barometry of the United States," as prepared by Prof. F. H. Bigelow and others.

1902. Daily forecasts sent by wireless from Nantucket, Mass., to Cunard Line steamers.

1902. The Weather Bureau purchased land for a research observatory at Mount Weather, Va. Regular station work began there in the autumn of 1904. The administration building burned October 23, 1907, but was rebuilt in the summer of 1909.

1904. September 20–22. The Third General Weather Bureau Convention met at Peoria, Ill.

1904. December 1. The marine meteorological work of the Government was returned to the Weather Bureau by the U. S. Hydrographic Office, and the Weather Bureau relinquishes its work in wireless telegraphy.

1905. June 29. Maximum and minimum thermometers placed on the summit of Mount Rose, Nev. (altitude 10,800 feet), by Prof. J. E. Church, jr., of Reno, Nev.

1905. December 3. Daily wireless messages from ocean vessels began to be used by the U. S. Weather Bureau in compiling weather maps.

1906. Mount Weather Research Observatory near Bluemont, Va., opened by the Weather Bureau. The purpose of this observatory is to conduct research in meteorology and allied sciences as applied to the practical work of the Weather Bureau. The first bulletin of the Mount Weather Observatory was published in January, 1908.

1907. June. The inauguration of daily upper-air observations at Mount Weather and the utilization of their results by the Forecast Division at the Central Office.

1907. June. Evaporation observations at Reno, Nev., by Prof. F. H. Bigelow, H. L. Heiskell, and others.

1907. September 20. Wireless reports of the Greenwich mean noon observations from vessels on the North Atlantic were discontinued.

1907. November. Regular evaporation observing stations were installed at Indio and Mecca, Cal., by the U. S. Weather Bureau.

1908. Publication of Prof. Ward's "Climate in Its Relation to Man."

1908. Forecasts for periods of a week to ten days in advance, based on daily telegraphic reports from the Atlantic, the Pacific, Europe, Asia, and Alaska, were begun by the Weather Bureau at Washington.

1908. Organization of the Inter-Bureau Service for observations on evaporation and water resources.

1909. The first Bulletin of the "Mount Rose Weather Observatory" was published. The further prosecution of this work under Prof. J. E. Church, jr., was made possible by the cooperation of the Mount Rose Weather Observatory, the Nevada Agricultural Experiment Station, and the State University.

1909. Publication of Weather Bureau Bulletin "S," "Temperatures and Vapor Pressures of the United States," by F. H. Bigelow and others.

1909. The Weather Bureau began evaporation investigations at the Salton Sea, California.

1909. The Smithsonian Institution publishes "The Mechanics of the Earth's Atmosphere, II." a collection of further translations by Cleveland Abbe.

1909. July. Beginning with the issue for this month the Monthly Weather Review changes its character and becomes a statistical survey of the weather. Professor Abbe is relieved of its editorship which passes to the Climatological Division under Professor Bigelow.

ADDENDA.

1836. J. P. Espy had been using wire in place of string for the kite cord for at least a year before this date.

1867. June. Cleveland Abbe, at Washington, D. C., studies the complex currents beneath thunder clouds by observing many kties flying simultaneously at various places and heights.

1871. December. The observations made on the balloon voyages of S. A. King are summarized by Prof. Cleveland Abbe and the law of change of wind with altitude deduced from them by him. He commends balloon work to the Chief Signal Officer.

1876. July. Prof. Cleveland Abbe determines, by means of kites, the altitude of the sea breeze on the coast of New Jersey.

1877. The Smithsonian Institution published "Short Memoirs on Meteorological Subjects," translations by Prof. C. Abbe.

1877. An outfit of pilot balloons, gas machine, and instructions how to use such balloons in determining the altitudes of the under sides of clouds, were furnished by Prof. Cleveland Abbe for the Arctic cruise of the schooner *Florence* (Capt. Geo. E. Tyson).

1879. July-August. S. A. King and Oray T. Sherman study the height and temperatures of the sea- and land-breezes at Coney Island, N. Y., by means of a manned captive balloon.

The end.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. Fitzhugh Talman, Librarian.

The following have been selected from among the titles of books recently received, as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies. Most of them can be lent for a limited time to officials and employees who make application for them. Anonymous publications are indicated by a ——.

Austria. K. k. Zentralanstalt für Meteorologie und Geodynamik.
Allgemeiner Bericht und Chronik der im Jahre 1907 in Österreich beobachteten Erdbeben. No. 4. Offizielle Publikation. Wien. 1909. x, 209 p. 8°.

Bombay and Alibag observatories.
Magnetical, meteorological, and seismological observations 1902 to 1905. Bombay. 1908. v. p. f°.

British association for the advancement of science.
Report ... 1908, Dublin. London. 1909. v. p. 8°.

Carnegie institution of Washington.
The California earthquake of April 18, 1906. Report of the State earthquake investigation commission. Washington. 1908. 2 v. Atlas. f°.

Craig, J. I.
Types of weather in Egypt. Alexandria. 1909. (Reprinted from "The Cairo scientific journal," no. 30, v. 3, March, 1909. 3 p.)

Davis, William Morris.
Atlas for practical exercises in physical geography. Boston. 1908. 45 pl. 8°.

Deutsche Südpolar Expedition 1901-1903.
... Hrsg. von Erich von Drygalski. 2. Band. Heft 3. Berlin. 1908. p. 225-298. f°.

Dry farming congress.
Formerly the Trans-Missouri dry farming congress ... Being a stenographic report of the proceedings of the third annual session of the congress held in Cheyenne, Wyo., February 23, 24, and 25, 1909 ... [Denver. 1909.] 360 p. 8°.

Dutch West Indies. Inspectie van den Landbouw.
Meteorologische waarnemingen ... Suriname en Curaçao ... 1908. [Paramaribo. 1909.] 16 p. 8°.

Eredia, Filippo.
L'alluvione nel versante orientale della Sicilia del novembre 1908, Roma. 1909. 20 p. 4°.
Pioggie torrenziali in Sicilia. (Dagli Atti dell'Accademia Gioenia di scienze naturali in Catania. Ser. 5. v. 2. 4 p.)

Finska vetenskaps-societeten.
Bidrag till kännedom af Finlands natur och folk. Häftet 64-66. Helsingfors. 1907-1908. 8°.
Öfversigt af ... forhandlingar. v. 48-50, 1905-1908. Helsingfors. 1906-1908. 8°.

Galitzin, B.
Hilfstabellen zur Auswerthung von Seismogrammen bei Anwendung aperiodischer Instrumente. St. Petersburg. 1908. 24 p. f°.
Seismometrische Beobachtungen in Pulkowa. 2. Mitt. St. Petersburg. 1909. 115 p. f°.

Germany. Deutsche Seewarte.
... Tabellarische Reiseberichte nach den meteorologischen Schiffstagebüchern. 6. Band. 1908. Berlin. 1909. x, 243 p. 4°.

Great Britain. National physical laboratory.
Report of the observatory department ... 1908. Teddington. 1909. 53 p. 4°.

Greely, A[dolphus] W[ashington].
Handbook of Alaska. Its resources, products, and attractions. New York. 1909. xiii, 280 p. 8°.

Heilprin, Angelo.
The eruption of Pelée. A summary and discussion of the phenomena and their sequels. Philadelphia. 1908. 72 p. xliii pl. f°.

India. Meteorological department.
Memorandum on the meteorological conditions prevailing before the southwest monsoon of 1909. Simla. 1909. 3 p. f°.

Indian association for the cultivation of science.
Report ... 1907. Calcutta. 1909. 65 p. 8°.

Keeling, B. F. E.
Climate changes in Egypt. (Cairo scientific journal. Alexandria. 1908-9.)

König, Fr.
Der Vertrocknungsprozess der Erde und Deutchlands verkehrte Wasserwirtschaft. Leipzig. 1908. 108 p. 8°.

Leyst, Ernst.
Luftelektrische Beobachtungen im Ssamark'schen Gebiet während der totalen Sonnenfinsternis am 14 Januar 1907. (Bulletin des Naturalistes de Moscou, no. 4, 1907. p. 493-528.)

Moscow. Kaiserl. Universität Meteorologisches Observatorium.
Beobachtungen ... 1907. Moscow. 1908. 4°.

Negro, C.
Contributo allo studio della dispersione elettrico-atmosferica. (Estratto dagli Atti della Pontificia accademia Romana dei Nuovi Lincei. Anno 62, Sess. 3 del 14 feb. 1909. 9 p.

Norway. Norske meteorologiske Institut.
Jahrbuch ... 1908. Kristiania. 1909. xii, 122 p. f°.
Nedboriagttagelser i Norge. Aargang 14. 1909. Kristiania. 1909. xvii, 130 p. f°.

Phin, John.
The evolution of the atmosphere as a proof of design and purpose in the creation and of the existence of a personal God ... New York. 1008. xiv, 191 p. 12°.

Saxony. Königl. sächsische Landes-Wetterwarte.
Wetterbericht. 1908. Dresden. 1908. n. p. f°.

Smithsonian institution.
Annual report. 1908. Washington. 1909. 138 p. 8°.

Société astronomique et météorologique de Port-au-Prince.
Bulletin annuel ... Année 1908. Port-au-Prince. 1909. 39 p. f°.

Soper, George A.
The air and ventilation of subways. New York. 1908. ix, 244 p. 8°.

Southport. Fernley observatory.
Report ... 1908. Southport. 1909. 29 p. 8°.

Steen, Aksel, S.
Havoverflatens temperatur ved Norges kyst. Kristiania. 1908. 17 p. 8°. (Archiv for mathematik og naturvidenskab. B. 29, Nr. 12.)

Trieste. I. r. Osservatorio marittimo.
Rapporto annuale 1905. 22 v. Trieste. 1909. 123 p. f°.

Wheeler, Joseph T.
The zonal-belt hypothesis. A new explanation of the cause of the ice ages. Philadelphia. 1908. 401 p. 8°.

Wilson, G. B.
Air-conditioning. Being a short treatise on the humidification, ventilation, cooling, and the hygiene of textile factories—especially with relation to those in the United States. New York. 1908. 143 p. 12°.

Yurief, [Dorpat]. University. Meteorological observatory.
Meteorologische Beobachtungen 1906. Jurjev. 1907. 93 p. 4°.

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Librarian.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers or other communications bearing on meteorology or cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled; it shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau. Unsigned articles are indicated by a ——

American geographical society. Bulletin. New York. v. 41. 1909.
W[ard], R. DeC. An interesting barometer. p. 388. (June.)
Hobbs, William Herbert. The Messina earthquake. p. 409-422. (July.)

Astrophysical journal. Chicago. v. 29. May, 1909.
Abbot, C. G., & Fowle, F. E., jr. Improvements and new results in solar constant determinations. p. 281-289.

Engineering news. New York. v. 61. June 17, 1909.
Flinn, Alfred D. Rainfall and runoff on the Croton drainage area, New York water supply, 1908-9. p. 650.

Journal of the Franklin institute. Philadelphia. v. 167. 1909.
Carter, Oscar C. S. Earthquakes in the light of the new seismology. p. 434-472. (June.)
Seely, Leslie B. Some problems of forestry. p. 1-18. (July.)

Manchester geographical society. Journal. Manchester. v. 24. 1908.
Ascoli, W. S. Guatamala: travels and experiences. p. 97-126. [Climate, p. 103-104.]

Nature. London. v. 80. 1909.
Lockyer, William J. S. Cloud photographs from a balloon. p. 310-311. (May 13.)
—— The Italian earthquake of December 28, 1908. p. 445. (June 10.)

Science. New York. v. 29. 1909.
Pollock, J. A. The ions of the atmosphere. p. 919-928. (June 11.)

Science. New York. v. 30. 1909.
Palmer, Andrew H. A remarkable aurora borealis. p. 57. (July 9.)

Scientific American. New York. v. 10. July 17, 1909.
—— Wireless telegraphy and meteorology. (Extr. Cosmos.) p. 41.

Scientific American supplement. New York. v. 47. June 19, 1909.
Wagner, A. The greatest altitudes attained by unmanned sounding balloons. p. 386.

Scottish geographical magazine. Edinburgh. v. 25. May, 1909.
Parkin, George R. The railway development of Canada. p. 225-250. [Climate and the development of Canada, p. 249.]

South African philosophical society. Transactions. Cape Town. v. 18. 1909.
Sutton, J. R. Earth temperatures at Kimberley. p. 421-435.

Symons's meteorological magazine. London. v. 44. June, 1909.
—— Georg von Neumayer. p. 83-86.

Annuaire météorologique. Bruxelles. 1909.
—— Bibliographie de la climatologie belge. p. 7-9.
—— Classification décimale des matières météorologiques. p. 10-19.
—— Comparaison d'evaporomètres. p. 20-24.
—— Comparaison de pluviomètres. p. 25-30.

Ciel et terre. Bruxelles. 30 année. 1909.
R., F. de. Télégraphie sans fil et météorologie. p. 144-146. (16 mai.)
Vincent, J. Georges Neumayer. p. 201-202.
Hellmann, G. L'aurore de la météorologie. p. 203-209. (16 juin.)
L[agrange], E. Phénomènes sismiques dans le midi de la France. p. 221-225. (1 juillet.)

France. Académie des sciences. Comptes rendus. Paris. Tome 148. 1909.
Hildebrandsson, H. Hildebrand. Sur la compensation entre les types de saison en certaines régions de la terre. p. 1559-1562. (7 juin.)
Bigourdan, G. Sur quelques tremblements de terre qui ont dévasté la Provence et le Dauphiné. p. 1568-1570. (14 juin.)
Angot, Alfred. Sur le tremblement de terre du 11 juin 1909. (14 juin.)
Bayeux, Raoul. Influence d'un séjour prolongé à une très haute altitude sur la température animale et la viscosité du sang. p. 1691-1694. (21 juin.)
Jullien, ——. Note sur l'emplacement des localités qui semblent avoir été le plus souvent éprouvées dans le tremblement de terre du 11 juin 1909. p. 1703-1704. (21 juin.)

Journal de physique. Paris. 4 ser. Tome 8. Mai 1909.
Millochau, G. La température du soleil et la constante solaire. p. 347-360.

Nature. Paris. 37 année. 1909.
Loisel, J. Les nuages. p. 405-408. (29 mai.)
—— Les sondages de l'atmosphère dans l'Est-Africain. p. 14 (suppl.)
—— Le tremblement de terre du Midi. p. 17 (suppl.). (19 juin.)
Rudaux, Lucien. Les hautes régions de l'atmosphère. p. 51-54. (26 juin.)
R., L. Les nuages et la distribution des végétaux dans les Pyrénées centrales. p. 29 (suppl.). (26 juin.)

Société belge d'astronomie. Bulletin. Bruxelles. 14 année. Jan. 1909.
Durand-Gréville, E. L'albe ou second crépuscule du soir. p. 9-25. (jan.)
Durand-Gréville, E. L'aube et l'albe. Premier crépuscule du matin et second crépuscule du soir. p. 163-173. (avril.)

Annalen der Hydrographie et maritimen Meteorologie. 37. Jahrg. Juni 1909.
—— Beitrag zur atmosphärischen Refraktion über Wasserflächen. p. 306-324.

Archiv der deutschen Seewarte. Hamburg. 31. Jahrg. 1908.
Köppen, W. Drei Jahre gleichzeitiger meteorologischer Drachenaufstiege bei Hamburg, Berlin und St. Petersburg. p. 3-12.

Globus. Berlin. Bd. 95. Juni 1909.
Eckhardt, Wilh. R. Ueber das Klimaproblem der geologischen Vergangenheit und historischen Gegenwart. p. 334-336. (10 Juni.)
—— Georges von Neumayer. p. 353-354. (17 Juni.)

Illustrierte aeronautische Mitteilungen. Strassburg. 13. Jahrgang. 5. Mai 1909.
Polis, P[eter]. Die Pilotballonstation des meteorologischen observatoriums zu Aachen. p. 365-367.

Meteorologische Zeitschrift. Braunschweig. Band 26. Mai 1909.
Trabert, W. Dr. Joseph Maria Pernter. p. 193-198.
Köppen, W. Vorschlag alle Luftdruckmessungen in allgemeinem Kraftmass anzugeben. p. 198-201.
Czermak, P. Zur Wolkenform des aufsteigenden Luftstromes. p. 210-212.
Köppen, W. Dr. Adolf Sprung. Nachruf. p. 215-216.
Ficker, Heinz von. Die Austrocknung Turkestans. p. 216-217.
—— Resultate der meteorologischen Beobachtungen zu Loanda. p. 230.
—— Resultate der meteorologischen Beobachtungen zu S. Vicente de Cabo Verde. p. 232.

Meteorologische Zeitschrift. Braunschweig. Band 26. Juni 1909.
Schmauss, A. Die obere Inversion. p. 241-258.
Kremser, V. Ergebnisse vieljähriger Windregistrierungen in Berlin. p. 259-265.
—— Ein meteorologisches Observatorium auf dem Pic von Teneriffa. p. 267.
——L. Teisserenc de Bort: Die Gesetze der vertikalen Temperaturverteilung unter verschiedenen Breiten und bei verschiedenen meteorologischen Verhältnissen. p. 267-270.
Schubert, J. Der Niederschlag in der Annaburger Heide 1901 bis 1905. p. 270-272.
Wegener, Kurt. Bemerkungen zu der Abhandlung "Zur Entstehung der Graupeln" von Dr. E. Barkow. p. 273-275.
Friesenhof, Gregor. Der Einfluss der Schneedecke auf die Bodentemperatur. p. 273-275.
Hann, J[ulius]. Klima am unteren Zambesi. p. 277-280.
—— Resultate der meteorologischen Beobachtungen in den Jahren 1904 bis 1906 zu Kayes (Franz. Sudan). p. 275.
Hann, J[ulius]. Resultate der meteorologischen Beobachtungen zu Timbuktu im Jahre 1905. p. 281-282.

Petermanns Mitteilungen. Gotha. 55. Band. 1909.
Woeikow, A[lexander]. Der Aralsee und sein Gebiet nach den neuesten Forschungen. p. 82-86.
Fitzner, Rud. Die Regenverhältnisse des Togogebiets. p. 93-94.
Mecking, Ludwig. Zum antarktischen Klima. p. 113-116.

Physikalische Zeitschrift. Leipzig. 10. Jahrg. 15. Juni 1909.
Gockel, A. Uber den Ursprung der Gewitterelektrizität. p. 396-398.

Weltall. Berlin. 9. Jahrgang. 1. Mai 1909.
Breu, Georg. Haben die Oberbayerischen Seen auf die Hagelbildung und Hagelverteilung einen Einfluss? p. 221-229.

Wetter. Berlin. 26. Jahrgang. Mai 1909.
Rudel, ——. Gewitterhäufigkeit zu Nürnberg 1879 bis 1908. p. 104-107.

Wiener Luftschiffer-Zeitung. Wien. 8. Jahrgang. 15. Juni 1909.
Fonvielle, Wilfred de. Meteorologie im Ballon. p. 195-196.

Nuovo cimento. Pisa. ser. 5. v. 17. Marzo 1909.
Bellia, C. Il potenziale elettrico dell'atmosfera sull'Etna. p. 174-178.

Reale accademia dei Lincei. Atti. Roma. v. 18.
Alessandri, C., & Eredia, F. Andamento diurno della temperatura dell'aria alla Cappanna Margherita e ad Alagna. p. 601–605.
Società spettroscopisti Italiana. Memorie. Catania. v. 38. 1909.
Bellia, C. Sopra il calcolo della costante solare. p. 94–104.

METHODS AND APPARATUS FOR THE STUDY OF EVAPORATION.

By C. F. MARVIN, Professor of Meteorology. Dated June 21, 1909.

[*Continued from the Monthly Weather Review, April, 1909.*]

II.—INSTRUMENTS.

The instruments described in the following pages were devised to meet the needs of the campaign of work upon the evaporation of water from lakes and reservoirs, which has recently been undertaken by the Weather Bureau.

Although some of the devices were made up fully two years ago, yet they have only recently been employed in actual observations, and the object of the present paper is to bring the new instruments to the attention of those who may wish to use apparatus of this character.

We mentioned in the first section[10] of this paper that our present studies are confined essentially to the phenomena of evaporation from free water surfaces, and the apparatus, therefore, is designed more especially for the measurement of evaporation of water from pans.

GENERAL METHODS OF MEASUREMENT.

No method is known by which we can directly measure the water evaporated from an extended surface of water, soil, ice, snow, etc., as they ordinarily occur in nature. All we can do is to isolate, for example, a pan of this water, soil, snow, or ice and ascertain how much it loses by evaporation from day to day or hour to hour. Two general methods are available, viz:

(1) The weighing method.
(2) The volumetric method.

All existing apparatus for measuring evaporation, with scarcely an exception, belong in one or the other of these classes. If a psychrometer, for example, is regarded as an evaporometer then we need to make a separate class.

The Weighing Method.

The weighing method when available is probably the most exact of any, and perhaps it alone can be employed in the measurement of evaporation from ice, snow, damp soils, growing vegetation, etc. This method, nevertheless, is subject to sharp limitations that often make it wholly unavailable. In many cases it is of great importance that the isolated mass of material be relatively very great as compared with the loss by evaporation in the interval between observations. To weigh the loss under such conditions will generally require costly balances operating under conditions that entail special difficulties, or may be wholly incompatible with the general possibilities of the situation. The weighing method is, therefore, generally unavailable in all extensive field observations.

The Volumetric Method.

The volumetric method resolves itself nearly always simply into the measurement of the depth of water remaining in the evaporating pan or other container. Important errors affect this method and must be carefully accounted for. Among these may be mentioned:

(*a*) The formation of waves and ripples on the water, rendering it difficult to define and measure the mean level of the surface.

(*b*) The wind may drive the water from the lee to the windward side of the pan, causing false readings of changes in level.

(*c*) If not very solidly supported small tiltings and mechanical alterations in the position of a pan may be caused every time an observer approaches it to make a reading. Serious errors may be made in the measurements by such causes.

(*d*) Pans of considerable size floating in the water, and other pans to a lesser degree, may sometimes undergo such mechanical deformations or volumetric alterations as to produce changes in the level of the water-surface that do not correspond to real evaporation.

All possible causes of error such as those we have mentioned must of course be very carefully eliminated. Even in those regions where evaporation is very active it must nevertheless be measured in units of hundredths or even thousandths of inches, and trained scientists are well aware that measurements of this order of exactness cannot be carried forward from day to day except by the aid of apparatus whose essential parts retain the most definite and invariable relations.

Evaporation pans.—Probably the most suitable apparatus for the study of evaporation from an extended water surface consists of a large pan of water provided with means by which the loss of water can be measured or automatically recorded. Experience has shown that the size of the pan and the distance of the water below the rim will make very little difference within reasonable limits of variation. This does not mean that the actual evaporation in a 2-foot pan, 6 inches deep, will be the same as from a 10-foot pan, 6 feet deep, for example. The temperature of the water in the two pans would doubtless prove to be very different; but when this and other differences have been fully taken into account the evaporation will generally be found to be quite the same.

The sheltering effect of the rim of the pan is always important and to minimize this pans of large diameter—4 feet or more—should be used as far as possible. In general the water surface may be kept within 2 inches, or even less, of the rim of the pan. A greater depth may be necessary if water is likely to be splashed out by strong winds. So, likewise, in regions subject to heavy rainfall the height of the rim must be great enough to prevent the overflow of the pan by heavy rains. Circular pans about 4 feet in diameter and 10 inches deep, made of galvanized sheet iron, constitute a good working size.

Rain-sheltered pans.—When rainfall occurs frequently and in considerable amounts it is practically impossible to accurately determine the evaporation if the rain is permitted to fall into the evaporation pan. In the writer's opinion the only plan to follow is to roof over the evaporation pan so that no rain can fall into the apparatus. This roof must not obstruct the perfectly free action of the wind underneath. A pan so exposed will of course show a different march of temperature conditions, but the evaporation equation which will ultimately be developed will take account of this and there are many great advantages in the use of rain-sheltered pans. This plan has been recently put in operation by F. De Willson on the Panama Canal Zone. Evaporation often goes on continuously during showers, as the air is not then necessarily saturated.

Installation of pans.—To avoid and minimize the errors due to change of position and deformation, mentioned above under (*c*) and (*d*), the customary galvanized sheet iron pans must be bedded as perfectly and evenly as possible on rigid supports, and when floated in the water the pans must be trussed and ribbed, or otherwise reenforced, so that deformations do not result from the gentle wave motions of the water.

The still-well.—We now come to the details of the actual measurement of the water that passes out of one of our evaporation pans. These measurements aim to locate accurately the level of the water surface at each observation, so that the lowering of the surface represents the loss of water by evaporation. Any exposed water surface is almost always disturbed by large or small wavelets so that some artifice must be resorted to that will suppress the wave motion and realize the equivalent level the water would assume if stationary. We

[10] Monthly Weather Review, April, 1909, 37:141.

shall apply the term still-well to any expedient that accomplishes this result.

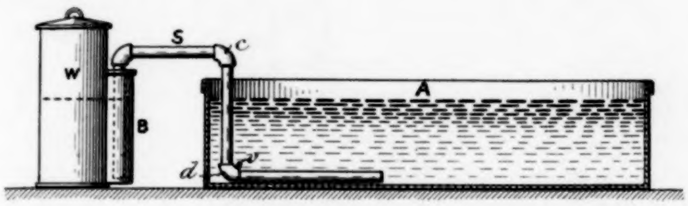


FIG 2.—Still-well and siphon (Marvin).

The writer has devised a form of still-well, shown diagrammatically in fig. 2, that can be varied to meet almost any set of conditions that generally arise. In the figure A is the evaporation pan, W is the still-well consisting of a separate vessel adapted to the particular purpose required. At B a small bay-window-like extension is securely soldered on the surface of W and the two chambers communicate with each other by means of a suitable hole in the wall of W near the bottom of B. The pan and still-well are put into hydrostatic communication by means of the siphon S which is made of the ordinary so-called ½-inch galvanized-iron water pipe. It was a long time before a satisfactory plan was hit upon for easily filling the siphon perfectly. The solution however was found in the vent-tube v, which is shown enlarged in fig. 3. A small pliable copper tube, vc, is run through a hole drilled in the angle of the elbow d and terminates as high up in the elbow c as practicable. It is not essential that the tube fit water tight in the elbow d. Thus constructed the siphon can be easily adapted to almost any situation, leaky joints are easily avoided and the absence of rigid connections between the pan and the still-well removes a possible source of error caused by small changes in the relations of the two parts due to variable mechanical strains, temperature changes and the like.

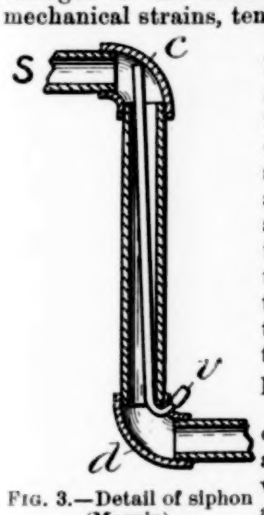


FIG. 3.—Detail of siphon (Marvin).

To fill the siphon a short piece of rubber tubing is slipped over the vent at v and the air deliberately sucked out of the siphon. W, of fig. 2, must of course contain sufficient water to seal the siphon in B. The operator will notice a distinct check in the outflow of the air when water enters the fine copper tube. This constitutes a definite signal that the siphon is full and the rubber tube may then be removed. It is better to incline the siphon a little so that the elbow c, while filling, is the highest point in the system.

The flow of water through a siphon of even ½-inch pipe is relatively slow, and consequently very considerable wave agitation in the pan produces no appreciable alteration of the free water surface in the still-well. It is generally best to carry the end of the siphon in the pan out to its center to minimize the errors due to tilting of the pan and to banking up of the water on one side by the wind.

Where the conditions are such that a still-well of relatively small dimensions suffice, it will be much better to make this an integral part of the pan itself. This plan should also be followed especially in the case of floating and suspended pans even when the still-well is of considerable relative size.

Errors incident to the use of still-wells, floats, etc.—Whenever a float is used on an evaporation pan, or a still-well employed, a certain source of error is introduced that is very easily corrected for, but the error is nevertheless often quite ignored. This is readily understood from fig. 4.

Suppose we are using a large float F riding directly upon the water surface of a pan. Obviously the surface from which evaporation takes place is not the whole area of the pan, but is this area *less* the sectional area of the float at the water line. On the other hand the movements of the float show only the changes of level of the whole water contents of the pan. If the area of the float is one-half the area of the pan then a given change in level of the float will indicate only one-half the actual evaporation, that is, such as would be shown by this same pan if without the float. The same thing results when a still-well is employed. Either designedly or incidentally there will be little or no evaporation possible from the water surface in the still-well, consequently all the evaporation takes place only in the pan while the change in level affects both the pan and the still-well, so that the indicated is always less than the actual evaporation depending on the relative sectional areas.

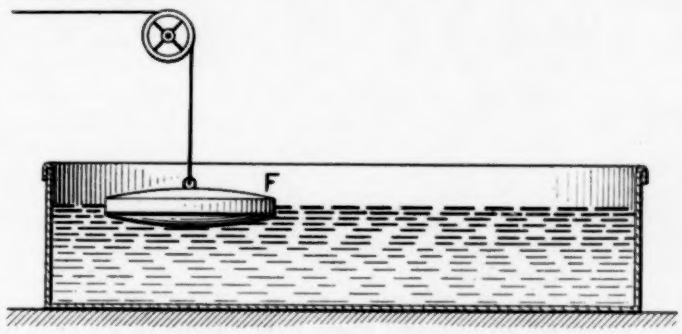


FIG. 4.—Illustrating still-well and float errors.

Let A = area of free surface of water that evaporates, and a = area of float or still-well. This area must include all free water surfaces not subject to appreciable evaporation and that are in hydrostatic communication with the evaporation pan. We shall then have: True evaporation = Observed change of level $\times \frac{A+a}{A}$. Suppose that the area of the still-well or float is 3 per cent of the area of the free evaporating surface. The foregoing expression means simply that all direct readings of the evaporation are 3 per cent too small and should be corrected accordingly. We shall point out later (p. 186) how the float and still-well error can be automatically compensated for in the measuring instruments themselves and thus avoid the tedious correction of observations and records otherwise necessary.

Having in one way or another established an undisturbed water surface, change of level may be measured by the aid of numerous devices that have been proposed or used. These will be described in two classes:

(*a*) Indicating gages, or those gages which require eye readings at certain regular intervals;

(*b*) Automatic recording gages.

(a) *Indicating Gages.*

The hook gage.—This well-known device has long been in use and scarcely needs description. A common form is shown in fig. 5. The point of the hook is raised from below the water surface upward by the aid of the screw until the point just punctures the water surface. This setting can be made with great exactness on a stationary water surface if a certain favorable kind of illumination is provided. Settings are a little tedious and may be very inexact during night observations or if the water surface is slightly disturbed. The scale is read by aid of a vernier.

The cup-and-pin method.—This method is also extensively employed. A slender pin is fixed permanently in the evaporation pan and rises to a sharpened point which marks the desired level of the water surface. The pin is best fixed in the

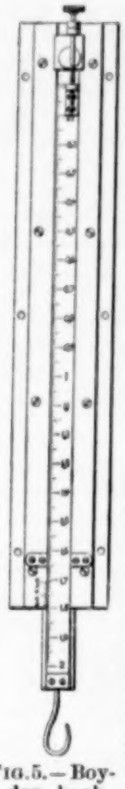


Fig. 5.—Boyden hook gage.

center of the pan and is often surrounded by a tube 2 or 3 inches in diameter so arranged as to realize the still-well conditions. A cup is likewise provided, the contents of which, when filled to the brim and emptied into the evaporation pan, raise the level a predetermined amount, say 0.01 inch. The number of cupsfull that must be added to or removed from the pan to restore the water surface to the level of the pin point represent the evaporation, rainfall, etc., in units of 0.01 inch. This method is also tedious if many cupsfull are required, also errors in the count of cups may easily be made, and the measurement made inexact by splashing and imperfectly filled cups. Obviously a large cup holding say 10 small cupsfull, and itself equipped with a pin point for filling to a definite volume constitutes a possible convenient accessory.

The Lehman pin-and-tank method.—The Weather Bureau official in charge at Birmingham, Ala., has employed a still more useful modification of the pin-and-cup method. His modification adapted to a floating pan is shown in fig. 6. A flower pot *F*, painted above the water line, fixed upon the upper end of the pin *P*, serves as a still-well, and is provided with a mirror *M* to render the point more easily visible. Water to supply that lost by evaporation is drawn from a small cylindrical vessel *A*, provided with a float actuating an index *I*, suspended from a silk thread. The motion of *I* over an appropriate scale shows evaporation in millimeters and tenths.

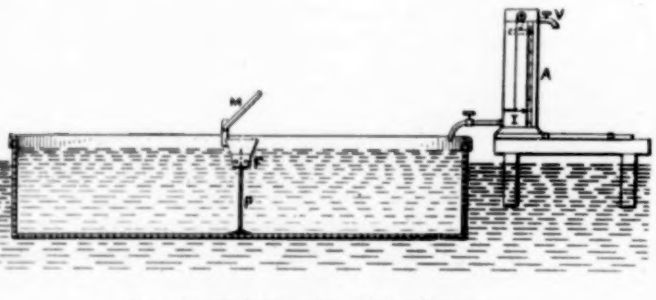


Fig. 6.—Lehman pin-and-tank gage.

The Marvin micrometer gage.—The micrometer gage is a modification of the hook-gage, and in one form or another has also been extensively employed.

Fig. 7 shows a form of the micrometer gage improvised by the writer from easily available material to supply Professor Bigelow's emergency needs at the time the Reno observations were undertaken. A still-well with transparent walls is formed by mounting an argand lamp chimney on the tripod supports shown. Three bits of blotting paper or cardboard[11] between the tube and plate suffice to provide any desired still-well relations of water flow. The millimeter micrometer screw and scale [see fig. 8] are carried on a metal spider, *S*, that rests on the top of the glass tube. Settings and readings to the hundredth of a millimeter can easily be made under favorable conditions. The feet of the tripod must be firmly soldered to the bottom of the evaporation pan for continuous service, but it seems the instructions to this effect were not carried out in the Reno and other observations made under Professor Bigelow's directions, and these excellent little instruments were practically discarded by him for general work.

[11] Abbe, who has been the only one to use this gage, substituted small slips of oilboard such as is used in letter-copying presses. This has the advantage of retaining its firmness after long submersion and thus not easily affecting the zero-point as used by him.—*C. A., jr.*

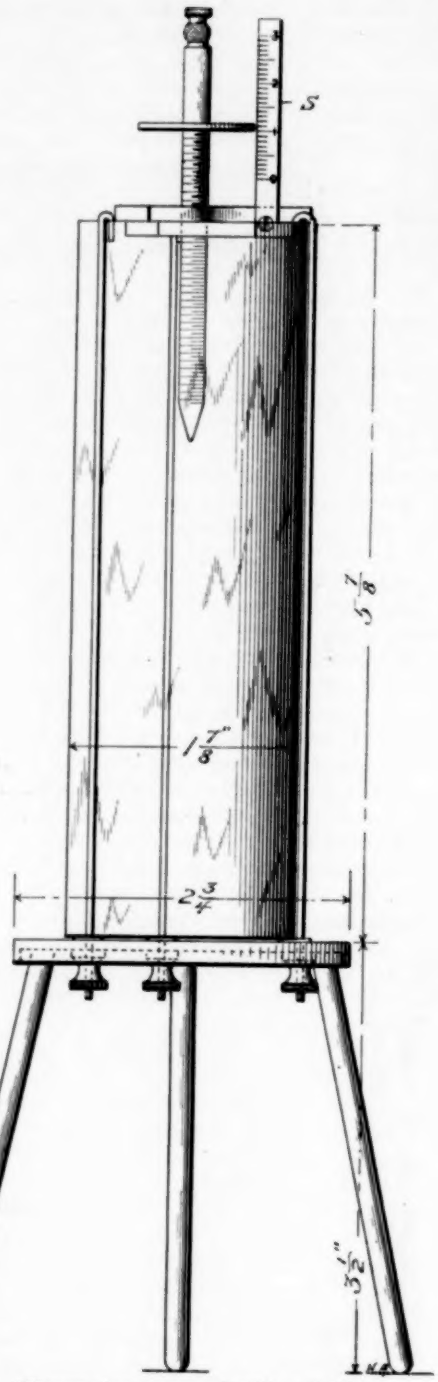


Fig. 7.—Micrometer gage and still-well (Marvin).

All the foregoing methods, if carefully employed, give accurate results under the aid of certain magnifying effects. The pin-and-cup method and its modifications are subject to rather serious constant errors if certain precautions are not observed in evaluating the scales. An error of 1 per cent in a linear measurement becomes an error of 2 per cent on a surfac and of 3 per cent in a volumetric result. Many otherwise careful workers will quite disregard this well-known mathematical law. Volumetric apparatus ought to be checked carefully by some sort of actual calibration.

The Bigelow burette gage.—This exceedingly simple device for measuring directly the depth of water in an evaporation pan was introduced by Prof. F. H. Bigelow when making his observations at Reno. It has since been extensively supplied

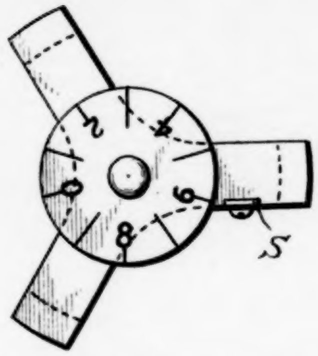


FIG. 8.—Micrometer head for the Marvin micrometer gage.

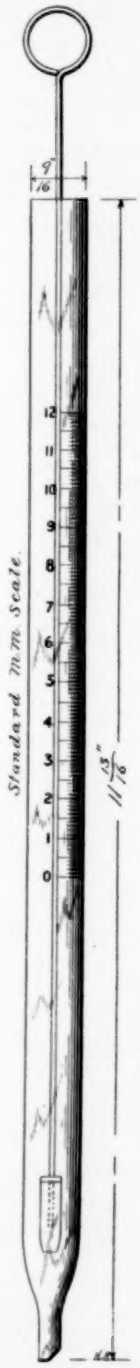


FIG. 9.—Simple burette gage (Bigelow).

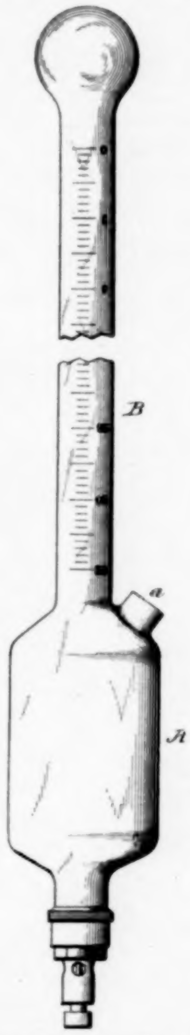


FIG. 10.—Magnifying burette gage (Marvin).

in the improved form, shown in fig. 9, to a number of observers at U. S. Irrigation Projects. Professor Bigelow preferred this apparatus to the more exact micrometers because of its simplicity.

A reading is made by placing the point of the tube upon some predetermined spot in the evaporation pan and necessarily this same spot must be used at each observation. The end of the tube is bevelled slightly to admit the water when the stopper is lifted. The graduated tube itself acts as a still-well and when filled the plunger is pushed into the end of the tube. A scale of millimeters engraved on the tube enables one to read off the approximate level of the water. Magnification is impossible with this arrangement and the errors of a reading are probably not less than half a millimeter which of course in many localities will exceed the evaporation for several hours. Such a device will doubtless answer very well where observations are made at wide intervals such as a day or week, but its errors are too large to show up satisfactorily the evaporation during short intervals such as three or four hours.

Marvin magnifying burette.—The Bigelow burette at once suggested to the writer a device by which the measurements could be read on a magnified scale. That is, we can collect the water from the pan in a relatively large tube and pour it into a smaller tube for measurement. The plan was promptly tried by means of an improvised arrangement, and its greater accuracy over the simple burette was shown by a large number of comparative readings made at Washington, D. C., in the summer of 1908. This burette is shown in fig. 10 and its adjustable pedestal in fig. 11.

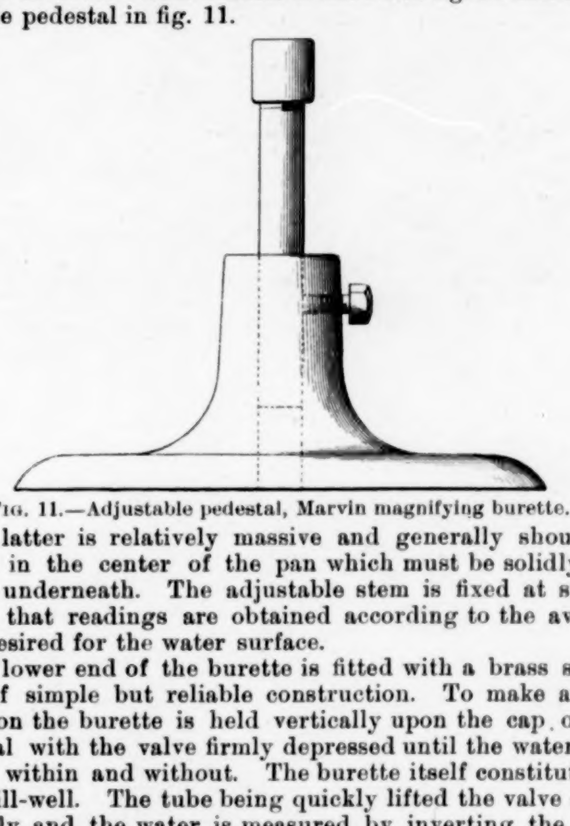


FIG. 11.—Adjustable pedestal, Marvin magnifying burette.

The latter is relatively massive and generally should be placed in the center of the pan which must be solidly supported underneath. The adjustable stem is fixed at such a height that readings are obtained according to the average level desired for the water surface.

The lower end of the burette is fitted with a brass spring valve of simple but reliable construction. To make an observation the burette is held vertically upon the cap of the pedestal with the valve firmly depressed until the water is at a level within and without. The burette itself constitutes its own still-well. The tube being quickly lifted the valve closes instantly and the water is measured by inverting the tube. The scale graduations are 0.2 millimeter (about 2 millimeters actually) and observers are expected to read to the nearest half of a scale graduation, thus realizing tenths of a millimeter in evaporation. The range of scale on the burette embraces somewhat over 30 millimeters and a standard method of manufacture has been perfected so that all burettes of this construction give exactly the same reading in the same pan at the same time. This, at least, is true within narrow limits.

Variations can be treated, if necessary, as instrumental errors just as we sometimes do in the case of thermometers.

It is well known that the adhesion of water to the walls of vessels and variations in drainage on walls temporarily wetted, always interfere with exact volumetric measurements in cases of this kind. These are best minimized by carefully following certain systematic methods of observation or, of course, by repeating readings several times.

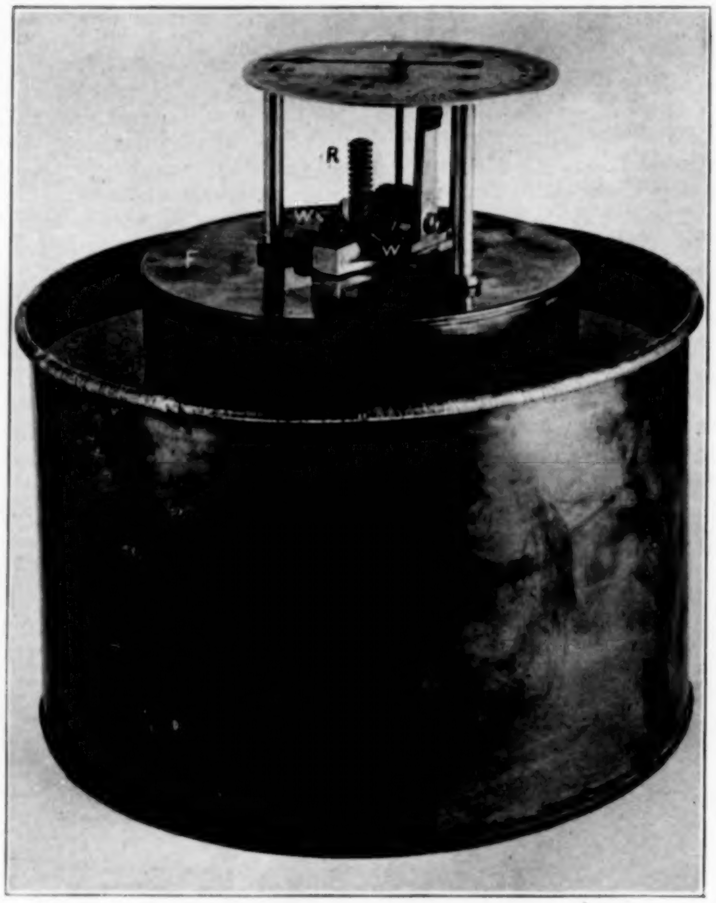


FIG. 12.—Floating micrometer and its still-well (Marvin).

All the devices that have been described thus far have one serious defect. The observer must carefully set and adjust the apparatus according to some fixed and generally more or less tedious method of proceedure. This wastes a good deal of time and exacts a good deal of patience. What we really need is a device that will show at a glance and on a magnified scale what the exact level of the water is at any moment. With such an instrument attached to each evaporation pan all an observer is required to do is to read the scale at each observation, and supply water to the pan from time to time. The instrument shown below in fig. 12 meets these requirements in an admirable manner.

Marvin floating micrometer.—The instrument consists essentially of a float *F* that rises and falls with the water surface in the most frictionless manner possible. The float carries a graduated dial and index hand which varies its position with the slightest changes in the level of the water surface supporting the float. In the model of this device at present in operation the dial embraces 30 millimeters change of level and the instrument is operative over a range of about 50 millimeters. The scale of magnification is about 10 to 1; the scale divisions represent 0.2 millimeter, and are over 2 millimeters actual size so that a reading to half a scale division gives tenths of millimeters on the record.

The mechanical means employed to secure these results are all very simple and of the most reliable character. The still-well in which the micrometer is mounted is provided with a central cylindrical brass stem, *R*, which passes up loosely in a hole through the center of the float. A cylindrical rack, *R*, is cut on a portion of the upper end of this stem, *R*, and a spur gear mounted on the float engages the teeth of the rack in a proper mechanical fashion. The float and gear are always retained in the proper relation by the aid of two little guide wheels, *W*, *W*, arranged for that purpose. Experience shows that a properly constructed gearwheel and rack can be made to engage in this manner and operate with scarcely any serious friction, and at the same time be free from objectionable shake or "lost motion" as the mechanic calls it. By making the rack *cylindrical* and placing it in the central axis of the float the latter is left perfectly free to rotate about the rack as well as to rise and fall with any variations of water level. This construction, in fact, realizes nearly perfect freedom from friction and the slightest changes of level are at once communicated directly and positively to the gearwheel engaging the rack. It remains only to further multiply this motion and render it measurable. For this purpose a crown wheel formed upon the side of the spur gear drives a small pinion and axle which carries the index hand at the top.

Other devices in which an index actuated by a float is caused to move over a graduated arc have been employed by others engaged in evaporation studies; but these are all subject to narrow and serious limitations and lack many of the distinct mechanical advantages realized in the floating micrometer here described. The float and its multiplying gears, index, and scale are all a self-contained mechanical unit easily manufactured to definite specifications. The dialing and gear-train have no stop points, but admit of indefinite and continuous motion in either direction. The cylindrical rack with its tripod foot also constitutes a separate and definite mechanical entity. To put these in working relation the float is simply lowered around the rack with only sufficient attention to let the teeth of the spur gear enter easily into engagement with the rack. No delicate adjustments or settings of any kind are necessary either when the micrometer is set in action or at times of observation.

The still-well must completely inclose the micrometer to prevent the action of the wind and to protect the mechanisms from dust, insects, etc. Readings can be made through a glass set in the top of the cover of the still-well, but dew is likely to form on the inside under certain temperature conditions. This can be prevented and the metal work protected at the same time against corrosion and the action of the water by adding a thin layer of some light, permanent oil, like kerosene. The form of still-well and siphon shown in fig. 2 prevents any oil getting over into the evaporation pan.

Automatic correction for still-well error.—In discussing the still-well [p. 183] we pointed out the error incident to its use and gave the mathematical expression for finding the true evaporation. The floating micrometer requires a still-well about 6 inches or more in diameter, that is, the still-well area may be about $2\frac{1}{2}$ per cent of the evaporating surface of a 4-feet pan. If, now, the dial indications show the changes of level of the float in *true millimeters* then the scale readings will not give the true evaporation but the quantities will all be $2\frac{1}{2}$ per cent too small. It is possible to arrange the train of multiplying gears so that this $2\frac{1}{2}$ per cent correction is automatically taken up in the motion of the hand. For example, when the float rises say 10 millimeters let the index move over exactly $102\frac{1}{2}$ scale units and we may thus obtain a correct indication of the evaporation.

The advantages offered by the floating micrometer, which

requires only to be read at each observation, seem to render it distinctly superior to any other device that has been thus far offered. It seems to the writer to be almost the only instrument that can be used successfully in the case of floating pans. For this purpose the pan itself must be made perfectly rigid and stiff by appropriate webs and bracing and the still-well must be an integral part of the pan, preferably occupying the center. This whole apparatus will ride on the water with only a relatively small vibration of the index over the scale. In general readings can be made at the limiting positions of the index hand so that a fair estimate may be made of the position of rest under rough weather conditions when scarcely any other method can be employed.

(b) *Automatic Recording Gages.*

In recording evaporation a serious difficulty is encountered in tracing the record of evaporation upon a sufficiently magnified scale and in recording with the same mechanism rainfall that occurs from time to time. To a certain extent these conditions are incompatible especially in regions of heavy rainfall and the best results are then, doubtless, obtained by the use of rain-sheltered evaporometers as referred to in a separate paragraph.

The writer, after an extensive study of the mechanical problems involved, has developed a form of recorder that seems to meet most of the requirements in a very satisfactory manner. The conditions which he has sought to satisfy may be stated thus:

(1) Ample scale of magnification, viz, 8 to 1 or greater.

(2) Small size of the record sheet without waste surface.

(3) Ability to record rainfall legibly under ordinary conditions, i. e., at rates as high as 5 or 6 inches per hour in quantities of 1 or 2 inches or more.

(4) General simplicity of mechanisms of a durable character, small size, portable, easy to install, etc.

Marvin's triple recorder.—These requirements are scarcely satisfied, as a whole, by any of the instruments that have been described heretofore, as far as known to the writer, but their realization must necessarily result in a very satisfactory form of apparatus.

In the instrument we have devised along these lines we have added a very important accessory, namely, a recording pen which traces a record of the wind movement by the aid of the ordinary anemometer installed in any manner desired in close proximity to the evaporation pan. Thus we obtain continuous records side by side on the same sheet of *rain, wind,* and *evaporation.* The original model of this instrument is shown in fig. 13, on a special base plate arranged to exhibit the mechanisms. In actual practice the whole instrument is inclosed in a compact metal case comprising the still-well. The distinctive feature of the instrument is found in the devices employed to magnify and inscribe the movements of the customary float resting on the water surface in a suitable still-well. For this purpose we use a small, fine, smooth gilded chain such as goldsmiths employ to string jewel necklaces. These chains are very strong and inextensible yet almost perfectly flexible. A piece of such a chain passes over a drum, *D*, causing it to revolve as the float, attached to one end of the chain, rises or falls with the water surface. A small counterweight, *W*, produces a sufficient tension on the chain. Increased driving effect can be gained by wrapping the chain one or more times about the drum, which is made of ample width of face for this purpose, or it may be screw-threaded if desired.

The axle of the drum is provided with a crown wheel and pinion combination, *C*, which greatly magnifies the effect of the slight motions of the float. The vertical axis of the pinion carries a crank disk at the top, which by the aid of a light pitman rod communicates a reciprocating movement to the pen carrier pivoted at *A*. The pen arm proper is pivoted in a fork *F* of the carrier. This construction serves the double purpose of permitting the pen arm to be lifted entirely back, clear of the record drum, and at the same time by the aid of a suitable weight at *a* the pressure of the pen point on the record sheet can be reduced to the minimum compatible with a perfect record. All these arrangements will be readily understood, it is believed, from an inspection of the illustration.

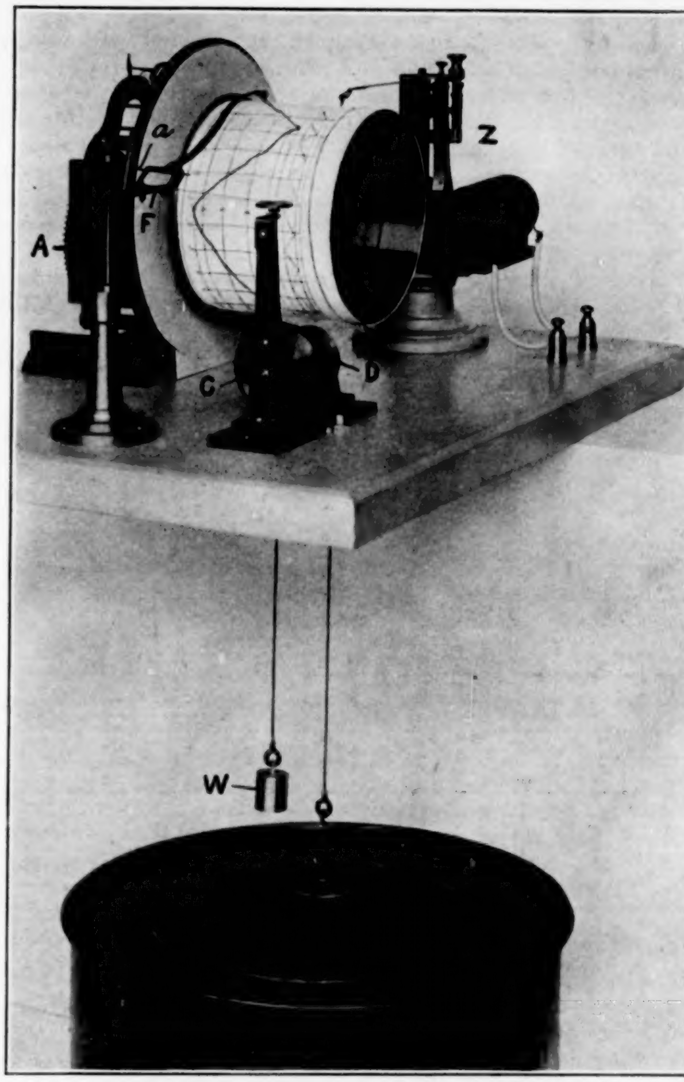


FIG. 13.—Rain, wind, and evaporation recorder (Marvin).

The mechanisms we have described involve the minimum amount of friction consistent with the work that is to be done, and to render the action as perfect as possible we employ small ball-bearing pivots of neat and simple design on the axle of the crown wheel and drum, which give the maximum strength with the minimum friction. The float required in recording evaporometers is often of seeming grossly disproportionate size. This is because excessive friction exists in the magnifying and inscribing mechanisms. For example, we must be able easily to read to tenths of a millimeter of evaporation and the recording pen must respond continuously to much smaller movements of the float than this. If the mechanisms stick slightly as the evaporation goes on steadily then the movements of the pen will take place by starts and jerks and this will give the record a steppy discontinuous appearance. A change of water level of one-tenth millimeter on a float 20 centimeters in diameter introduces a moving force of 3.1 grams. This is quite adequate to move the multiplying and

recording devices we have employed and experience shows that a float of this size gives a smooth and continuous record.

Form of record.—When the float moves continuously downward, for example, the pen reciprocates back and forth across a prescribed space upon the record sheet. The dimensions of the drum and the ratios of crown wheel, pinion, crank arm, and pen levers are such that the pen makes one transit across the sheet, 40 millimeters, when the float moves 5 millimeters, thus realizing an average magnification of 8 to 1. Owing to the use of a crank wheel the scale of magnification follows the well-known law of sines and is a maximum in the middle portion of the record and a minimum at the margins. This can be avoided by the substitution of a heart-shaped cam for the crank disk, and this arrangement has been tried, but it necessarily involves more friction. The writer finds no serious objection to the use of the crank disk which is preferred on account of the simpler construction involved and the absence of friction.

Figure 14 shows a portion of a daily record sheet, actual size. Its explanation will make clear the operation of the instrument.

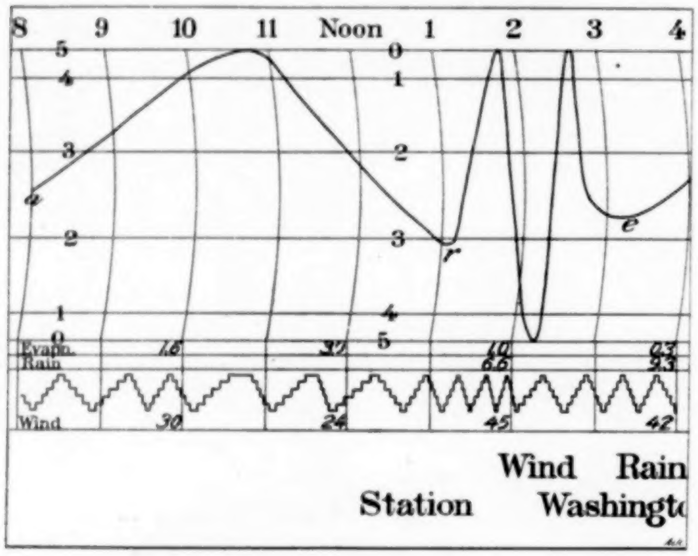


FIG. 14.—Record of the Marvin rain, wind, and evaporation recorder.

The longitudinal lines numbered 1, 2, 3, etc., represents millimeters or other units of evaporation. The vertical lines represent hours of time. The record starts at the left, the trace beginning at *a* indicates evaporation continuously up to *r*, when about 5.6 millimeters of evaporation had been recorded. At this point the pen stopped and began to move backward without having reached the limit of its reciprocation; this means that rain caused the float to rise, i. e., from the point *r* to the next reversal of the motion between the margins of the sheet, for example at *e*, the record represents rain. The record beyond *e* must be read as evaporation. It may seem at first thought that the rain and evaporation can not often be separated. This, however, is hardly the case. There are two reasons why it will generally be easy to disentangle such composit records. *First.* The change from evaporation to rain and vice versa, will almost always fall between the margins of the record and any reversal of the motion of the pen, *between the margins of the record* always means a change from evaporation to rain, or from rain to evaporation. *Second.* The rate of evaporation is always very slow and mostly regular, whereas rain falls at very irregular and often at very rapid rates. It is, of course, possible that rain may, for example, begin to be recorded just as the pen reaches the margin of the sheet so that the actual reversal of the motion of the float is not discoverable on the face of the record. In such cases we must rely on the other characteristics to differentiate the records, and it is believed that difficulties and confusion of records on this account will be inconsequential.

Wind record.—The device Z employed to record the movement of the wind is the zig-zag apparatus used at U. S. Weather Bureau stations in the registration of rain and sunshine.[12] Its reliability has been abundantly demonstrated by years of satisfactory service. The record needs but little explanation. Each step in the zig-zag trace represents a mile or a kilometer of wind movement. These fall in groups of five up and five down or vice versa, that is, each complete apex, $\wedge$, represents ten miles or kilometers, etc. Notwithstanding that the record sheet moves at the slow rate of less than half an inch per hour yet this device enables us to inscribe a perfectly legible record of winds of such extreme velocities as 90 to 100 miles or kilometers per hour.

The record sheets must be changed each day, but records can easily be provided for upon a continuous ribbon of paper, if required. Good results in evaporation, however, require frequent attention to the water in the evaporation pans, which often becomes quickly fouled and must be refreshed and the level of the surface maintained at a proper point below the rim of the pan. On these accounts the writer is strongly in favor of daily records, and the slight attention to the apparatus thus entailed greatly enhances the value of the record.

Evaluation of record sheet.—The scheme proposed for evaluating and tabulating the recorded data is indicated in fig. 14. The data is read from the record for intervals of two hours each. Thus, in fig. 14 the evaporation during the first two hours of the record was 1.6 millimeters; from 10 hours to 12 hours the amount shown is 3.0 millimeters, etc. These amounts are set down on the record sheet in the spaces provided; the rain

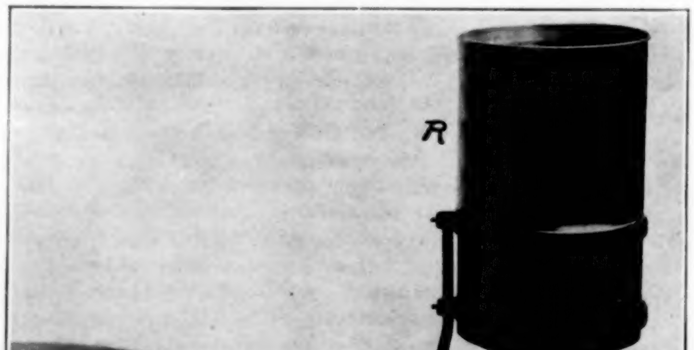


FIG. 15.—General view of the recording evaporation gage, tipping-bucket system (Marvin).

[12] A detailed description of this attachment is given in W. B. Publ. No. 364, Anemometry, Circular D, Instrument Division. 1907.

and the wind being treated in the manner just explained for evaporation.

Tipping-bucket electrical recorder.—The measuring mechanisms of this apparatus are shown assembled in working arrangement in fig. 15. The rectangular box and cover shown at *B* serves as a still-well in connection with the evaporation pan, and contains a tipping-bucket device operating in conjunction with a float so as to replace the water lost by evaporation and record the amounts thus supplied. The water required for this purpose is drawn from the reservoir, *R*, through an electrically-operated valve imperfectly seen at *V*. (See also fig. 17.)

The float and tipping-bucket mechanisms are shown diagramatically in fig. 16, at *F* and *B*, respectively. The float is poised on a delicately supported multiplying lever *L*. As the level of the water slowly falls from loss by evaporation, the free end of the lever, *L*, rises in a magnified proportion. A small electromagnet located near the end of the lever is actuated momentarily once each minute by a contact in the clock of the register. Ordinarily nothing results from this action, but sooner or later the free end of the lever rises to such a point that it is caught and pinched by the closure of the electromagnet. The pinching of the end of the lever when

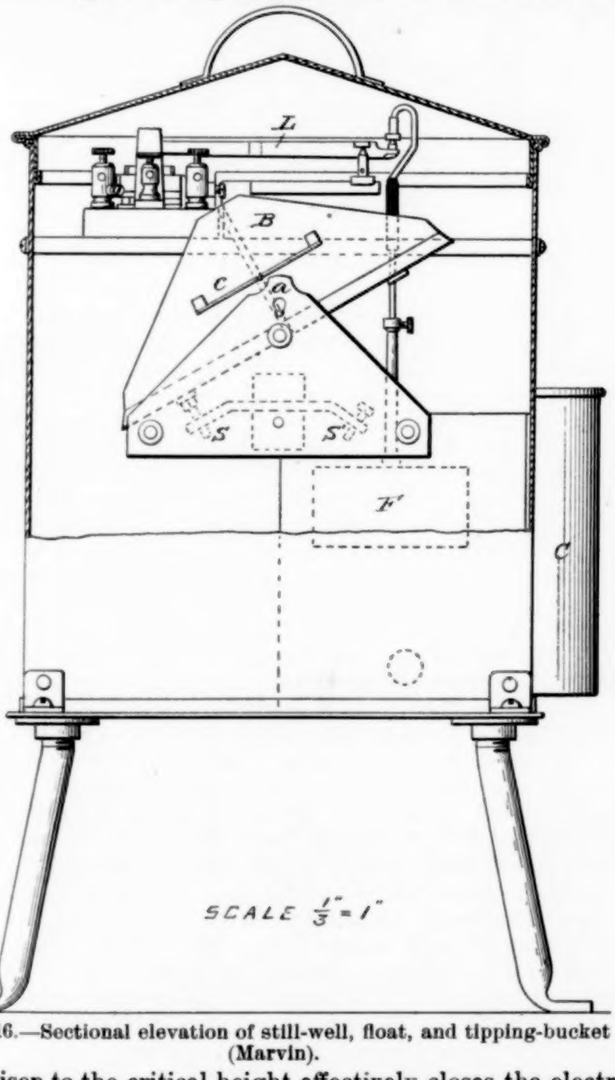


FIG. 16.—Sectional elevation of still-well, float, and tipping-bucket (Marvin).

it has risen to the critical height effectively closes the electric circuit through the valve *V* shown in cross-section in fig. 17. This starts the flow of water from the supply tank, *R*, and the tipping-bucket is quickly filled. The electric currents for all these operations pass through the stop pins, *S*, *S'*, upon which the tipping-bucket alternately rests. Consequently, the instant the bucket starts to tip the electric circuit is opened, the flow of water cut off, the free end of the lever released and the float elevated by the water emptied from the tipped bucket. The flow of the water from the still-well to the evaporation pan is slow and deliberate, and since the float, *F*, is itself inclosed within a small compartment, oscillations are most effectually suppressed. In the tests of this apparatus at Washington before it was sent for use at the Salton Sea, the action of the mechanism was very regular, positive, and free from trouble.

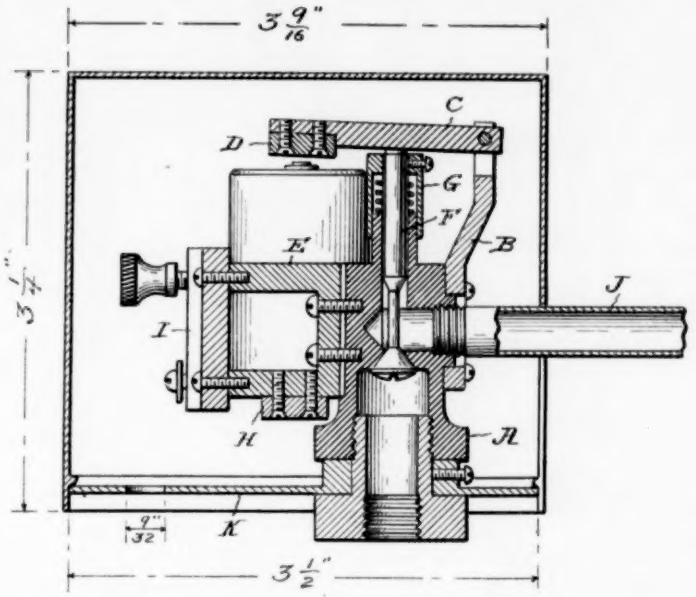


FIG. 17.—Sectional elevation of electrical valve, Marvin tipping-bucket recording gage.

The mechanisms operate whenever the loss by evaporation amounts to 0.05 millimeter, and each tip of the bucket is electrically recorded by the aid of contacts made by the spring, *c*, at *a*, fig. 16. This record is made on the standard register extensively employed at Weather Bureau stations for the registration of rainfall by the aid of the tipping-bucket device.

Auxilliary Apparatus.

The study of evaporation requires a knowledge of the

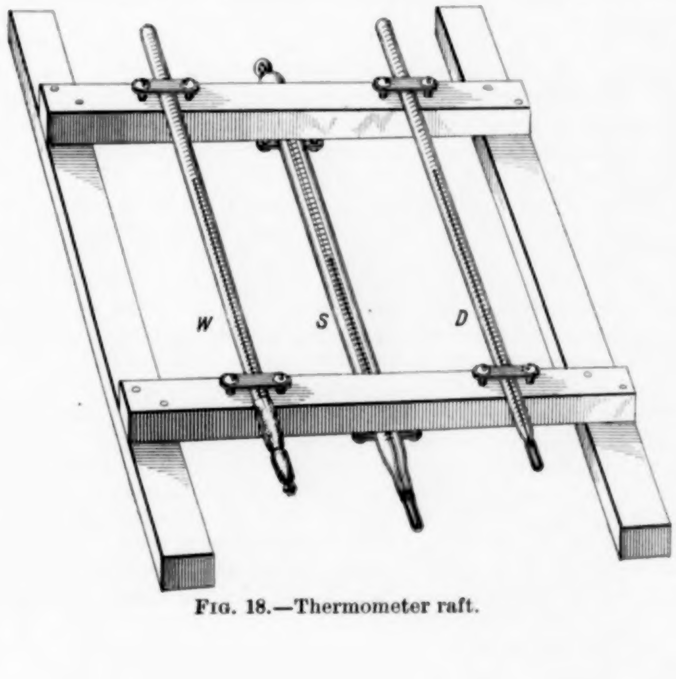


FIG. 18.—Thermometer raft.

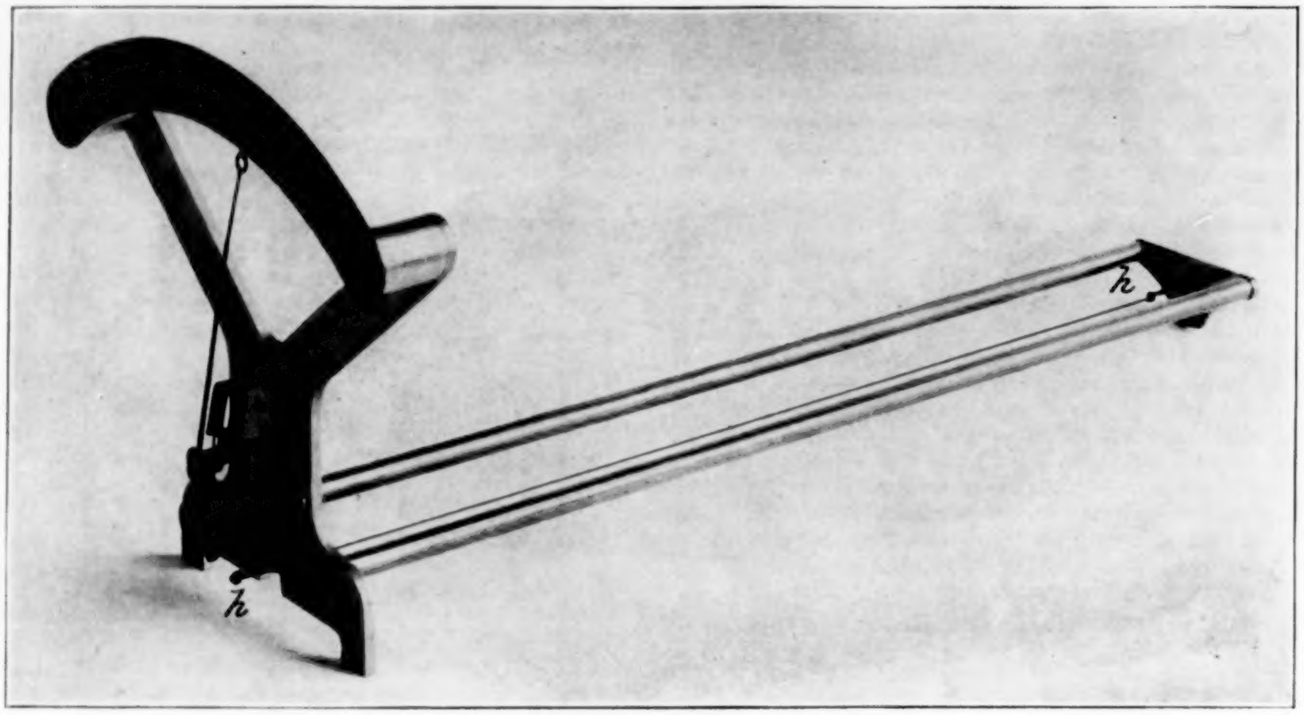


FIG. 19.—Hair hygrometer (Marvin).

velocity of the wind, the temperature of the water surface and the temperature and moisture content of the air at one or more points in the near vicinity of the evaporating surface. Some instruments and devices suitable for these purposes are shown in figs. 18 to 20.

Anemometer.—This well-known instrument requires no special description. The chief complication in its use arises from the difficulty in placing it in a position such that its record gives a true measure of the wind movement over the surface of the water whose evaporation is being studied. A number of observers when discussing evaporation data have used wind observations from anemometers many feet above and often at considerable distances from the evaporation pans. Accurate conclusions are quite improbable under such conditions.

The thermometer raft.—This arrangement was devised for Professor Bigelow's Reno observations and is shown in fig. 18, with the proportions and spacings finally adopted. When floating on a water surface the bulb of the thermometer, *S*, is just submerged and gives the temperature of the water surface. This thermometer is of the well-known glass-jacket construction with the scale of graduations inside the jacket tube. The two remaining thermometers are carried about one centimeter above the water surface, the bulb of *W* being properly covered with muslin, a loose end of which dips into the water, so that the combination, *W, D*, serves as a psychrometer for the purpose of giving a measure of the temperature and vapor pressure near the surface of the water.

The results obtained by this arrangement can not be regarded as highly accurate. In the first place, no attempt is made to cut off radiation and insolation; secondly, the ventilation of the psychrometer is quite inadequate, except when there is a good wind blowing. At such a time the readings of the instruments no doubt give very nearly exact values.

There is, however, another cause of error that is mostly overlooked. In the use of these rafts up to the present time, the practice has been to place the raft in the water of the pan a few minutes before each observation. Now, during periods of comparative calm the blanket of vapor near the water surface becomes nearly saturated for a considerable thickness. Careful observations made by the writer show that it is impossible to place the thermometer raft in the water without completely breaking up the vapor blanket. Consequently, observations made in this manner when the air over the evaporation pan has been relatively quiescent for some time are likely to show a much smaller vapor pressure than existed before the vapor blanket was disturbed by the operations incident to placing the raft and making the observations.[13]

Hair hygrometer.—The writer has used the form of hair hygrometer shown in fig. 19 for making studies of the vapor blanket very near the water surface. The slender strand, *h, h*, of a few hairs can be placed parallel to and, if desired, very near the water surface.

The hair hygrometer can hardly be regarded as a reliable primary instrument, but by frequently checking its readings with the sling psychrometer entirely reliable results are possible while its great sensitiveness and other qualities enable one to get data which can hardly be obtained otherwise.

Sling psychrometer.—This well-known instrument is shown in a convenient form in fig. 20 and scarcely requires further description. Faulty results have attended the use of the sling psychrometer at some of the evaporation stations from a disregard of the long-standing instructions respecting the wet-bulb covering. Only thin, finely woven, linen or muslin should be used and, if new, this must be thoroughly washed in clean water before applying to the bulb, so as to completely remove sizing, etc. The covering must be first wetted to apply to the bulb, and be carried up around the stem above the

[13] In Abbe's observations at Indio, Cal., in November, 1907, the psychrometer was uniformly whirled in the air over the center of the pan and as close as feasible to the water surface. This procedure churns the air and disturbs the vapor blanket in a much more serious manner than the mere placing of the raft in position, so that observations thus obtained in still air must be erroneous.—*C. A., jr.*

bulb for a distance of half an inch or more, so as to cool this part of the thermometer as well as the bulb. It must be wrapped close and tight for not more than one and a half turns around the bulb. The free end below the bulb must be tied in closely and left projecting for an eighth of an inch or more. The psychrometric formula and tables are computed for this sort of covering. Failure to wash out the sizing in new muslin or a wrinkling of the covering so that it fails to fit the bulb closely, is likely to give erroneous readings.

FIG. 20.—Sling psychrometer (Marvin).

METEOROLOGICAL OBSERVATORY AT TENERIFFE.

We are pleased to announce that the Spanish authorities are cordially cooperating with the International Aeronautical Commission and the German Government in supporting the high-level meteorological observatory on Teneriffe. It has been decided to open the doors of the observatory to qualified investigators of all nationalities.—*C. A., jr.*

THE RELATIONS OF THE INVERSIONS IN THE VERTICAL GRADIENT OF TEMPERATURE IN THE ATMOSPHERE TO AREAS OF HEAT AND COLD.

By HENRY HELM CLAYTON. Dated Readville, Mass., March 2, 1909.

When recording instruments are sent aloft on kites or balloons they show that, at least in the lower air, the temperature usually falls with increasing height above the ground; but there are belts or regions where the temperature rises with increasing height above the ground. These regions of rising temperature have received the name of inverted gradients. The belts of inverted gradient play an important part in atmospheric phenomena. They separate the air into strata with marked contrasts in humidity, wind velocity, and cloud formation. Usually the maximum of humidity and the clouds are immediately below the inverted gradient, but sometimes this condition is reversed. Usually there is a maximum of wind velocity within or very near each inverted gradient which occurs within 4,000 meters of the earth's surface. There are undoubtedly many other important relations to meteorological phenomena which remain to be disclosed.

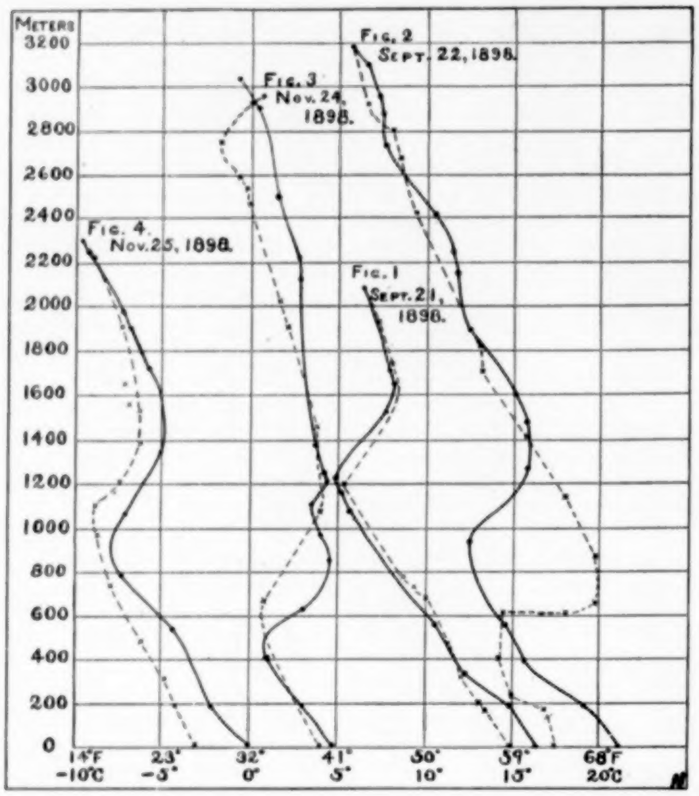
Studies of these inversions have been made by Rykachev,[1] Assmann,[2] A. J. Henry,[3] and myself.[4] The conclusion which I reached[4] from a study of the data at Blue Hill was that "*the belts of inverted gradient reached their greatest distance from the ground about the time of minimum temperature, and were nearest the ground about the time of maximum temperature.*"

In a recent study of the records obtained with kites and sounding balloons on the expedition of M. Teisserenc de Bort and Professor Rotch in the trade wind region, I found that the inverted strata dipped from about 40° north to the heat equator and then rose again in southern latitudes. Hence, I am led to conclude that it is a general law for the inverted gradients of temperature to incline upward from regions of warmth toward regions of cold, and vice versa.

The reason of this rule is probably because air flowing from regions of cold towards regions of warmth has a descending component of motion and the inclination of the inverted gradient indicates the angle of descent. On the other hand air moving from regions of warmth toward regions of cold is ascending and the inclination of the inverted gradient indicates the rate of ascent. But ascending air is expanding and cooling so that in time the moisture in such inclined ascending currents becomes condensed into cloud and in this way is undoubtedly to be explained the presence of stratiform clouds such as nimbus, alto-stratus, cirro-stratus, which are found immediately beneath these inverted gradients.

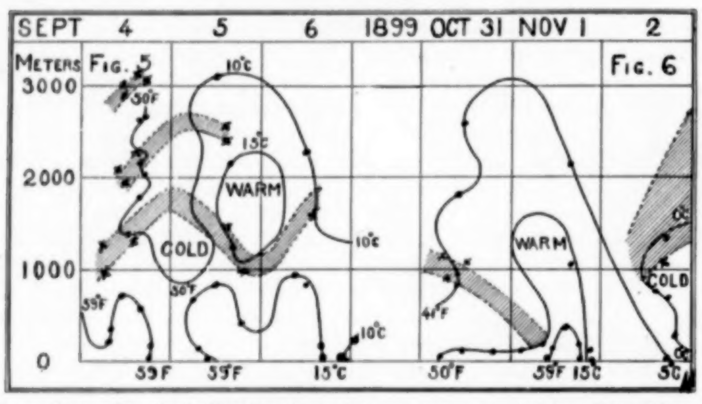
How the inverted gradients dip downward as the temperature of the air in which they occur rises and how they ascend as the temperature falls is here illustrated by some examples taken from my discussion of the observations at Blue Hill in Bulletins No. 1, 1899, and No. 1, 1900, of the Blue Hill Meteorological Observatory. Figs. 1 and 2, in the accompanying diagrams, show plots of the temperatures recorded at different heights on September 21 and 22, 1898, when the temperature was rising. Dots connected by a continuous line show the points where the temperature was read from the records made during the ascent of the kite and crosses connected by a broken line show the temperatures during the descent of the kite. It is seen from fig. 1 that the inverted gradient was between 1,200 and 1,700 meters during the ascent on September 21. By the morning of September 22, see fig. 2, the temperature had risen some 10° to 15° F., and the inverted gradient had descended several hundred meters. During the descent of the kites on the afternoon of the same day the inverted gradient had descended to within 650 meters of sea-level.

[1] Meteorol. Zeitschr., Hann-Band., p. 174.
[2] R. Assmann, Beiträge z. Physik d. f. Atmosph., 1:39.
[3] Bul. Mount Weather Observ., 1908, 1, pt. 3:143.
[4] Bul. Blue Hill Meteor. Obs., 1900, No. 1:7, 11.



FIGS. 1, 2, 3, 4.—Vertical gradients of temperature at Blue Hill, Mass., in September and November, 1898.

Figures 3 and 4 show plots of the temperature with relation to height on November 24, 25, 1898, days when the temperature was falling. It is seen from the figures that the inverted gradient was lowest during the ascent of the kites on the morning of November 24, when it was between 500 and 700 meters. At later observations it was found successively higher until the descent of the kites on the afternoon of November 25, when the inversion was between 1,100 and 1,500 meters. The temperature in the meantime had fallen about 10 degrees at the ground and 15 degrees at 1,000 meters.



FIGS. 5, 6.—Vertical distribution of temperatures at Blue Hill, Mass., during successive days in September, October, and November, 1899.

When the temperature observations are plotted in relation to time and height, as in figs. 5, 6, 7, and 8, and the inverted gradients are indicated by shaded areas, these are seen to form belts which rise and fall inversely to the isothermal lines, so that they are highest in cool areas and lowest in warm areas. The great upper air inversion at above 10 kilometers apparently conforms to the same law, rising and falling inversely with the temperature in the upper air, but the proof of this is not yet conclusive. In these cuts dots and crosses indicate some of the points where observations were obtained.

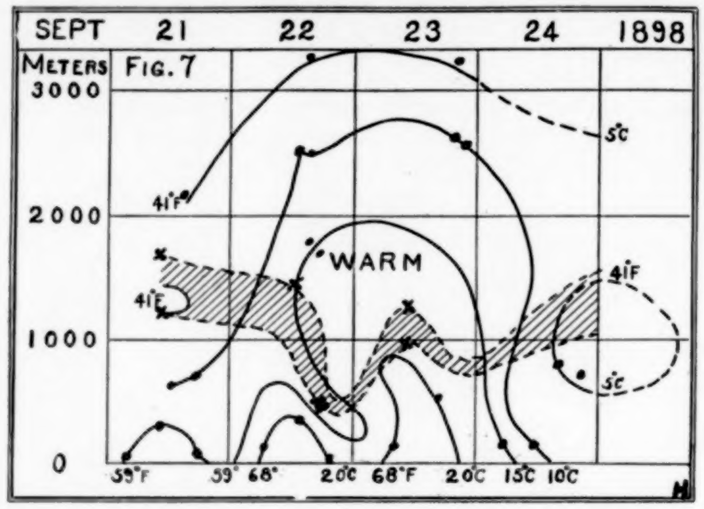


FIG. 7.—Vertical distribution of temperatures during September 21, 22, 23, 24, 1898, at Blue Hill, Mass.

In fig. 7 the diurnal rise in a belt of inverted gradient due to its being pushed upward by ascending currents from the heated ground is well shown on September 23. In such a case the belt rises to a maximum altitude during the afternoon and sinks again at night. This usually happens whenever the belt is within a thousand meters of the earth's surface. This diurnal rise interrupts and to some extent reverses the regular variation in height which takes place during the passage of warm and cold waves. All the apparent exceptions to the dipping of the belts toward regions of warmth are traceable to this diurnal period.

When the belt of inverted gradient is very near the ground, as in fig. 8, the ascending currents from the heated ground break through the belt and ascend to higher levels. When the belt is broken up in this manner during the day it strangely reappears at about the same height toward evening.

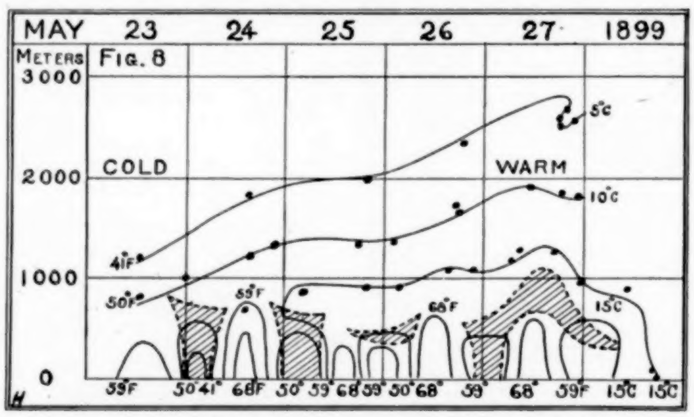


FIG. 8.—Vertical distribution of temperatures, May 23-27, 1899, at Blue Hill, Mass.

Since the air beneath a rising inverted gradient is colder than the air previously existing at the same level, the diurnal rise in the inverted gradient produces some curious anomalies in the diurnal period in the free air. For example, on September 23, 1898 (fig. 7) and May 27, 1899 (fig. 8) the temperature at 1,000 meters was lower in the afternoon than in the morning and evening of the same days. In other words, the ordinary daily change in temperature observed at the ground was reversed.

Occasionally a rapidly ascending body of air, on account of

its momentum and inertia, will rise through the belt of inverted gradient and form a temporary cloud of the cumulus or fracto-cumulus type at a level somewhat above the general level of the belt. In such cases the air in the cloud is colder than the air on either side of it, and it may be some 10° to 20° F. colder.

AN ANNOTATED BIBLIOGRAPHY OF EVAPORATION.

By MRS. GRACE J. LIVINGSTON. Dated Washington, D. C., January 8, 1908.

[*Continued from the Monthly Weather Review, April, 1909.*]

1897—*Continued.*

Fortier, Samuel.
Seepage water of northern Utah. Water sup. and irr. papers, 1897, No. 7: 17–24, 26, 43.

The apparatus consisted of a galvanized iron pan 36 by 36 by 10 inches floated in the reservoir. A diagonal bar scale permitted readings of the level to 1/100 inch. Tables of the evaporation at Fort Douglas, near Salt Lake City, Utah, for 1889–93, and at Fort Collins, Colo., 1887–91, are presented together with Russell's (1888) table of evaporation from the Piche atmometer at various localities in the United States. The total annual evaporation from water surfaces in Utah is estimated as from 3 to 6 feet, the evaporation during the dry season (May–August) of this region being equal to that of the other eight months. Gives a table of the relation between the crop harvested and the amount of evaporation. Under Logan river is discussed the relation between the rainfall and evaporation.

Houdaille, F.
Causes de vitesse maxima d'évaporation sous le climat de Montpellier. Ann. école nat. agr., Montpellier, 1897, **9**:286–95. Notice in Exp. sta. rec., 1897, **9**:1032–3.

The ratio of evaporation from the instrument previously described (Houdaille, 1890) to that from the Piche is given as 1.32. The mean daily evaporation (1875–84) varies between 3.23 millimeters in January and 9.35 millimeters in July. Gives the diurnal evaporation, temperature, humidity, and wind for January to September, 1896. Concludes that the wind is not an important factor in that locality, temperature and humidity being the main factors influencing evaporation there.

Krebs, Wilhelm.
Das Messen der Verdunstungsenergie mit dem Doppelthermometer. Met. Zeits., 1897, **14**:273–6.

Derives a formula for calculating evaporation directly from the readings of the psychrometer. Both Krebs and Ule (1897), claim priority in devising this method.

Latham, B.
Tables of evaporation from a 12-inch floating tank and a 5-inch exposed tank at Croydon, 1888–1897. Brit. rainf., 1897, (—):30–34.

Also gives illustration of Latham's evaporometer.

Madrid, Observatorio de.
Treinta años de observaciones meteorologicas, Madrid, 1860–94. Madrid. 1897.

Tables of the mean daily evaporation, 1860–94, from an exposed dish of water, accompanied by a table showing the lowering of temperature caused by evaporation. The average daily evaporation varies from 1.0 millimeter in January to 9.8 millimeters in July. The cooling effect varies from 1.3° C. to 9.1° C. for the same months. No yearly totals are given.

Pallich, J. von.
Ueber Verdunstung aus einer offen kreisförmigen Becken. Sitzber. k. Akad. Wiss. (Vienna), math. naturw. Kl., 1897, **107**(pt. 2a): 384–410.

Concludes that the ellipsoidal surfaces of equal vapor pressure above an evaporating surface, as mathematically derived by Stefan (1881), have too small an excentricity as compared with curves experimentally derived, and that this difference becomes more pronounced with higher temperatures. In the case studied this eccentricity should be 95 instead of 51 as given by Stefan's equation.

Royal Meteorological Society.
Exhibition of meteorological instruments in use in 1837 and 1897. Quart. jour. roy. met. soc., 1897, **23**:221–36.

On page 234 Pickering's (1898) atmometer is described; also a new Richard self-recording evaporometer. In this new pattern a sheet of blotting paper is kept moist by a wick which draws water from a closed reservoir. A float transmits to the pen the height of the liquid in the reservoir.

Rafter, Geo. W.
Stream flow in relation to forests. American Forestry Association, 1897, 12. Reprinted in Ann. rpt. Fisheries, Game, and Forest Commission for 1896. 1898.

An extensive discussion of the persistence at about the same rate, of the amount of evaporation from any given stream through long periods of time.

Symons, G. J. and H. Sowerby Wallis.
Records of evaporation. Brit. rainf., 1897, (—):28–34.

Gives the evaporation during 1897 at the usual stations, and also Latham's tables for 1888–97.

Ule, Willi.
Messung der Verdunstungsenergie mit dem Doppelthermometer. Met. Zeits., 1897, **14**:382–3.

Claims priority in the employment of the psychrometer to indicate the evaporating power of the air. (See Abbe, 1888, Krebs, 1895, 1897, and Ule, 1891.)

1898.

Abbe, Cleveland.
Evaporation and temperature. Mo. weather rev., 1898, **26**:213–4.

Summary of the work of Carpenter, 1898.

Bedford, Duke of.
See Pickering, S. U., and the Duke of Bedford.

Carpenter, L. C.
The loss of water from reservoirs by seepage and evaporation. Colorado Exp. sta. bul., 1898, No. 45. Abstract in Mo. weather rev., 1898, **26**:213. Abridged in Symons's met. mag., 1898, **33**:116–9.

Evaporation at Fort Collins, Colo., (alt. 4,990 ft.) from 1882–97, as measured by means of a hook-gage, gave an annual average of 40.94 inches. General discussion of the factors influencing evaporation. Unless the temperature of the water surface is warmer than the dew-point, evaporation can not proceed and condensation may occur. Evaporation from ice was 1.0 to 1.5 inches per month. The nocturnal evaporation, contrary to the general opinion, was almost the same as the diurnal, and these amounts approach equality as the body of water increases in size. Tabulates observations at many localities and altitudes in Colorado and California. He finds that the factors tending to decrease evaporation at high altitudes are lower temperatures, smaller differences between the vapor pressure at water surface temperature and that at the dew-point, and the decreased capacity for moisture of air at lower temperatures. Concludes that, although lessened air pressure and probable increased velocity of the wind at high altitudes favor evaporation, the annual rate is much less than at low altitudes.

Carpenter, L. C.
Losses of evaporation from canals. Records kept for two years on stretches of canals for irrigation purposes. Colo. Exp. sta. bul., 1898, No. 48. Summary in Exp. sta. rec., 1899, **10**:795–6.

Evaporation from canals is believed to be insignificant as compared with seepage, while in the case of reservoirs evaporation is the more important source of loss. The total depth of water lost from canals in the prevailing Colorado soils is estimated at from 1 to 2 feet per day over the whole surface of the canal, being less in clay soils than in sand or gravel.

Carpenter, L. C., and others.
Evaporation at the Colorado station. Colo. Exp. sta. bul., 1898, No. 49. Abstract in Exp. sta. rec., 1899, **10**:1019.

Results similar to those published in first title; repeats his formula published in 1888.

Gravelius, H.
Berichte über den Stand der Niederschlagsforschungen. Zeits. Gewässerk., 1898, **1**:341.

Reviews Heinz, 1898, who compared evaporation as observed at 15 stations in European Russia from 1871–95. A rapid increase in the annual evaporation is indicated in the direction from northwest to southeast: St. Petersburg, 331 millimeters; Vishni Volotshek, 352 millimeters; Moscow, 434 millimeters; Skopin, 572 millimeters; Nikolaiiev (Saratof), 643 millimeters; Astrakhan, 750 millimeters. The yearly maximum occurred nearly everywhere in July and the minimum in January. Relations between the rainfall and evaporation are pointed out. Attention is drawn to the fact that experiments with evaporation from a grass surface have been conducted at Pavlovsk by means of Rykachev's (1900) atmometer since 1896.

Grunsky, Carl Ewald.
Irrigation near Fresno, Cal. Water sup. and irr. papers, 1898, No. 18:74–8.

Finds the loss of water from canals is less by evaporation than by seepage.

Heinz, E. A.
Ueber Niederschläge, Schneemenge, und Verdunstung in der Flussgebieten des Europäischen Russland. St. Petersburg. 1898. Review in Selsk. Khoz. i Lyesov., 1898, **109**:716–7. Notices in Met. Zeits., 1898, **15**:(77); Exp. sta. rec., 1898, **10**:327

Reviewed by Gravelius, 1898.

Héjas, André.
A zivatarok magyavországon az 1871 töl 1895—ig terjedö megfigyelések Alapján. (Die Gewitter in Ungarn nach den Beobachtungen von den Jahren 1871–95.—Kurzer Auszug des ungarischen Originales.) Budapest. 1898.

The original gives, on p. 50–1, the daily evaporation during March to October, for the years 1890–5, at Budapest. The average daily rate varied between 1.20 millimeters for March and 3.92 millimeters for July.

Maxwell, W.
Evaporation and plant transpiration. Jour. Amer. chem. soc., 1898, **20**:469–83. Reviewed in Exp. sta. rec., 1899, **10**:721–2.

Experiments were conducted at the experiment station at Honolulu, T. H., on the amount of moisture directly evaporated from the soil, and the relative proportion that escapes by transpiration from sugar cane during the different periods of growth. The transpiration from sugar cane growing in a tub was observed for 270 days, together with the outdoor and indoor evaporation of water in small galvanized evaporators, temperature, humidity, direction of wind, etc. The amount evaporated outdoors during this time was 33.480 cubic centimeters, with an average temperature of 75.9° F.; that indoors was only 14.175 cubic centimeters, with a temperature of 79.9° F. The humidity was the same in both cases. The inference is that the wind exerts a greater effect upon the rate of evaporation than the temperature.

Mazelle, E.
Verdunstung des Meerwassers und Süsswassers. Sitsber. k. Akad. Wiss. (Vienna), math.-naturw. Kl., 1898, **107**:(pt. 2). Also reprinted Vienna, 1898. 20p. 8vo. Abstracts in Ciel et terre, 1899, **20**:267–8; Anz. k. Akad. Wiss. (Vienna), math. naturw. Kl., 1898, no. 7, **35**:49–50.

Daily observations from June 1, 1896, to September 30, 1897, at Triest, with two Wild atmometers of similar construction and exposure, one containing fresh water, the other a 3.73 per cent salt solution, showed that the ratio between the results approached nearer unity as the rate of evaporation from the fresh water increased. An equation in which x is the evaporation from the fresh water, and y that from the salt water, shows the following relation: $y = -0.018 + 0.7303x + 0.0561x^2 - 0.0044x^3$. The total amount evaporated from the fresh water was 910.6 millimeters, that from the salt water 750.9 millimeters, the ratio being 100:82.46. Complete tables compare these rates of evaporation with other meteorological factors.

Mohn, H[enryk].
Grundzüge der Meteorologie. Berlin. 1898. (5th ed.)

See Mohn, 1875.

Pickering, S. U., and The Duke of Bedford.
A new form of evaporimeter. Woburn exp. fruit farm rpt. for 1897, p. 168-74. Also quoted in Exp. sta. rec., 1898, **9**:533.

The object of this instrument is to approach as nearly as possible to the conditions governing the leaves of a tree. It consists of a sheet of any absorbent material, held vertically by means of a movable copper frame in a vessel of water fitted with a graduated side tube. The evaporating sheet ends in a tongue which dips into the water and is thus kept moist.

Symons, G. J., and H. Sowerby Wallis.
Records of evaporation. Brit. rainf., 1898, (—):36-44.

Gives the evaporation at seven different stations; describes Miller's sand evaporator, and gives its records for 1879-98. See H. Sowerby Wallis for succeeding records.

Wollny, E.
Untersuchungen über die Verdunstung und das Produktionsvermögen der Kulturpflanzen bei verschiedenem Feuchtigkeitsgehalte der Luft. Forsch. Geb. Agr. Phys., 1898, **20**:528, Also Centbl. Agr. Chem. (Biedermann), 1900, **29**:289-90.

Experiments on the relation between transpiration and plant growth.

1899.

Angot, Alfred.
Traité élémentaire de météorologie. Paris. 1899.

A general discussion of the process and laws of evaporation and various methods of measuring it, occurs on p. 173-5.

Galli, D. Ignazio.
Atmidometro a livello costanto. Atti accad. pont. nuovi Lincei, 1899, **52**:157-8. Also Mem. accad. pont. nuovi Lincei, 1900, **17**: 165-82.

This evaporometer consists of two communicating cavities in a solid block of marble, one containing powdered marble, the other closed and filled with water which is drawn by capillarity to the surface of the powdered marble, where it is allowed to evaporate.

Gravelius, H.
Ueber Verdunstung. Zeits. Gewässerk., 1899, **2**:248-52.

The run-off of a region is regarded as a function of the rainfall, evaporation, seepage, and the amount of water used by the vegetation. Describes Rykachev's apparatus (1900) for measuring evaporation from soil.

King, F. H.
Irrigation and drainage. New York. 1899.

The transpiration of plants and the slow rate of evaporation from a dry soil are dealt with on p. 46-54 and 98.

Minssen, Guilherme.
Lyceu Rio Grandense de Agronomia de Pelotas. Contribuiçao para o estuda da Climatologia do Rio Grande do Sul. Observaçiónes meteorologica feitas durante o anno de 1899.

Weekly observations at Pelotas, Brazil (lat. 31° 30′ S.), of evaporation from water, with monthly and yearly totals for 1899; also weekly, monthly, and yearly averages from 1893-9. The results show an antipodal yearly march of evaporation comparable with that of the northern hemisphere. The monthly average during 1893-9 varied from 66.5 millimeters in June to 140.1 in December, the annual average being 1157.7 millimeters.

Raulin, F. V.
Résumé des observations atmidométriques (évaporation) faites dans la Peninsule Ibérique de 1857 à 1890. Ann. soc. mét., 1899. Reprinted Tours. 1899. 20 p. gr. 8vo.

Wallis, H. Sowerby.
Records of evaporation. Brit. rainf., 1899, (—):31-4.

Table of evaporation at Camden Square, London, 1885-99. Evaporation records for 1899 at eight stations, five of which use the standard tank, 6 by 6 by 2 feet, are published, together with a table of the observations at Croydon by Baldwin Latham.

1900.

Brown, H. T., and F. Escombe.
Static diffusion of gases and liquids in relation to the assimilation of carbon and translocation in plants. Phil. trans., 1900, **193**: 283-91. Abstract in Annals of Botany, London, 1900, **14**:537-42.

The rate of diffusion of aqueous vapor through small apertures is controlled by the linear dimensions of the aperture and not by the area; the velocity of flow varies inversely as the diameter of the opening. Critically reviews other work along this line, especially that of Stefan (1873).

Davis, Walter G.
Clima de Córdoba. Ann. ofic. met., 1900, **13**:492-505, 573-97.

This report contains very complete tables of temperatures of evaporation, and of comparative rates of evaporation from six dishes of different size, material, and exposition. The temperature of evaporation was shown to be lower than that of the air, the difference averaging 3.81° C. for the year. The greatest difference was 4.81° in September and the least 2.70° C. in June. The hourly means for 1889-98 are tabulated. The comparative observations were made with (1) two brass dishes 10 centimeters deep, exposing 314 square centimeters surface, one in the thermometer shelter, the other fully exposed to the weather; (2) two Wild balances, whose dishes have a surface of 250 square centimeters and a depth of 45 millimeters at the edge and 30 millimeters in the center, having the same exposure as the metal evaporators; (3) a glass dish exposing 380 square centimeters evaporating surface and 13 centimeters deep exposed near the other evaporators; (4) a square, zinc-lined tank of brick, 80 centimeters deep and exposing a surface of 1 square meter. This tank is buried in the ground so that its water level is at the level of the contiguous soil and about 10 centimeters below the edges of the tank. The water level is read by a micrometer screw. Readings were taken every two hours, night and day, with all the instruments, except the glass dish and the tank which were read only once in 24 hours. The results of all these instruments are compared in detail and a study is made of the influence of the direction and force of the wind upon evaporation. The amounts of evaporation in 2 hours corresponding to increments of 5 kilometers in wind velocity are tabulated separately.

Escombe, F

See Brown, H. T., and F. Escombe.

Exner, Felix M.
Messungen der täglichen Temperaturschwankungen in verschiedenen Tiefen der Wolfgangsees. Sitzber. k. Akad. Wiss. (Vienna), math. naturw. Kl., 1900, **109** (pt. 2a):905-22.

A table of the evaporation accompanies other meteorological data.

Latham, B.
The climatic conditions necessary for the propagation and spread of the plague. Quart. jour. roy. met. soc., 1900, **26**:37-94.

The greatest amount of evaporation or exhalation would take place with the maximum temperature of the ground and the minimum dew-point, and it is shown that the rise and fall of these differences agree in a remarkable manner with the rise and fall of the plague. Taking into consideration the wind and its influence on evaporation, the author used Dr. Pole's formula for calculating evaporation: $E=\frac{T^2-t^2}{A\,(100-w)}$, in which T equals the temperature of the ground, t the temperature of the dew-point, and w the wind velocity in miles per hour. A equals a coefficient, 80 for Bombay, and E is the evaporation or exhalation in depth per day in inches. Diagrams show curves of the ten ional difference agreeing with that of death from plague in Bombay.

Lippincott, Joseph Barlow.
Storage of water on the Gila River, Arizona. Water sup. and irr. papers, 1900, No. 33.

Quotes (p. 32-4) evaporation observations by the U. S. Geological Survey in Arizona and estimates the rate of evaporation from the reservoir at Buttes, Ariz.

Maluschitski.
On the value of evaporometric observations to agricultural practice. Izv. Moscov. selsk. khoz. inst. (Ann. inst. agron. Moscou), 1900, **6**:325-403. Abstract in Exp. sta. rec., 1901, **13**:427.

Studies the evaporation from a free water surface and from soils. For a free water surface Michelson and Wild atmometers were used, and Wild's was found the more reliable. Evaporation from soil was determined by means of large zinc lysimeters. From his own experiments and a survey of the literature the author concludes: "Since the structure of the soil and the state of its surface exert an immense and varied influence on the stored-up humidity, as well as on the evaporation, no correlation can be established between the evaporation from a water surface and that from a cultivated soil, and still less in the case of a soil covered with plants."

Rykachev, M.
New evaporometer for the study of the evaporation from grass and observations with it in 1896 at the Constantine Observatory. Zhur. opuitn. agron. (Russ. Jour. exp. Landw.), 1900, No. 1, **1**:115-7. Abstract in Exp. sta. rec., 1901, **13**:428.

This apparatus consists of three rectangular zinc boxes, the outer one sunk in the ground, the other two fitting tightly into it, one above the other, the upper one containing soil with sod. Excess of rain water percolates into the middle box and maintains a constant degree of humidity in the lower layer of the upper vessel. The amount lost by evaporation is determined by weighing the upper and middle boxes together. The temperatures of the soil and of the water in the lower box were recorded. The indications of this instrument were found to be two or three times greater than those of a Wild atmometer.

Saussure, Horace Bénédicte de.
Versuche über die Hygrometrie. Neuchâtel. 1783. Herausgegeben von A. J. Oettingen. 2 vol. (Ostwald's Klassiker der exakten Wissenschaften, Nos. 116, 119. Leipsic. 1900.)

See Saussure, 1783.

Scott, R. H.
Results of percolation experiments at Rothamsted, September, 1870, to August, 1899. Quart. jour. roy. met. soc., 1900, **26**:139-51.

Table I gives the annual amount of rain, and of percolation as measured at three depths, 20, 40, and 60 inches, in gages similar to those described by Lawes, Gilbert, and Warington, (1881). Table II gives the monthly average for the entire period, and also the same grouped into half-yearly periods, September to February and March to August. Table III gives the actual monthly measurements for each year of the series. The evaporation may be obtained by subtracting the amount of percolation from the amount of rain.

Wallis, H. Sowerby, and Hugh Robert Mill.
Records of evaporation. Brit. rainf., 1900, (—):46-9. Abstract Met. Zeits., 1902, **19**:281.

Comparative tables of evaporation at various stations. Summarizes results at Camden Square for 1885-1900 and Latham's results at Croydon.

Warington, Robert.
Lectures on some of the physical properties of the soil. Oxford. 1900.

Evaporation from a free water surface, from bare soil, and from soil covered with vegetation are discussed in some detail on. p. 107-26, quoting results of Ebermayer, King, Greaves, etc.

1901.

Abbe, Cleveland.
The rainfall and evaporation of Great Salt Lake. Mo. weather rev., 1901, **29**:68-91

Quotes A. J. Henry's table of the rainfall over the water-shed of Great Salt Lake, and estimates the rate of evaporation from salt water by applying Russell's (1888) observed rate from a fresh water surface.

Alberti, Vittoria.
Sul clima di Napoli, riassunto generale delle osservazioni meteorologiche fatte nella R. Specula de Capodimonte 1888-1900. Atti. r. ist. sci., Naples, **3**:(ser. 5), No. 4. Reprinted, Naples. 1901. 24 p.

Page 82 gives the monthly and annual evaporations at Naples from 1886-1900, with five-year means. The annual average is 730 millimeters, the maximum monthly rate, 100.1 millimeters (August), and the minimum, 34.4 millimeters (February).

Balch, E[dwin] S[wift].
Evaporation under ground. Mo. weather rev., 1901, **29**:545. Abstract in Exp. sta. rec., 1901, **13**:828.

Maintains that underground evaporation does not cause an appreciable lowering of temperature and that the cold within ice caves must be wholly due to the low temperatures of winter.

Bok, O.
Die Breusch. Zeits. Gewässerk., 1901, **4**:1-48.

A table on p. 45 gives the mean monthly depth of evaporation, together with results of

observations of evaporation in meadow and forest, and the differences for the years 1891–5. Tables of rainfall, air temperature, relative humidity, and the water level of rivers are added.

Carpenter, L. C., and R. E. Trimble.
Meteorological observations for 1900. Colo. exp. sta. 13th Ann. rpt. Denver. 1901. 56 p.

Evaporation observations similar to those described in 1889. The monthly means during the years 1887–1900 vary from 1.24 inches in December to 5.63 inches in July. The mean annual evaporation was 41.16 inches and the average annual rainfall, 14.14 inches.

Chandler, Albert E.
Water storage on Cache Creek, California. Water sup. and irr. papers, 1901, No. 45:36–7.

Gives a table of the annual evaporation from Clear Lake, near San Francisco, for the years 1874–99, as observed by the State Engineering Department of California.

Davis, Arthur Powell.
Hydrography of the American Isthmus. Ann. rept. U. S. Geol. Survey, 1900–01, (—), Part iv, p. 507–630.

The evaporation from pans floating in Lake Nicaragua was observed at four stations. The monthly amounts for 1900 varied from 3.46 inches in August to 6.08 inches in May; the total amount for the year was about 52.4 inches.

Galli, D. Ignazio.
Esperienze coll' evaporimetro a livello costante. Atti accad. pont. nuovi Lincei, 1901, **54**:94.

In August, 1900, the author inaugurated comparative observations of evaporation of water in similar atmometers, one placed in the shade, but freely exposed to the wind; the other in the sun all day. No results are given. (See also Galli, 1899.)

Grunsky, C. E.
Water appropriations from King's River. In report of irrigation investigations in Cal., prepared by Elwood Mead. California exp. sta. bul., 1901, No. 100:259–325.

The experiments made by the California State Engineering Department under William Hammond Hall in 1881–5 at Kingsbury on King's River are described in the Appendix, p. 323–5. Two pans 36 by 36 by 15 inches with the water surface 5 inches below the rim were used, one floated in the river, the other placed on the bank. The average annual evaporation from the former was 3.851 feet, and from the latter 4.958 feet. The temperature of the water in the floated pan and of the river water were usually the same, while the water temperature in the pan on the ground varied considerably, being sometimes higher and sometimes lower than that of the river water.

Hann, Julius.
Lehrbuch der Meteorologie. 1st edition. Leipsic. 1901. 805 p.

A general survey of evaporation on p. 207–12. The phenomenon is defined as a function of temperature, humidity, wind velocity and air pressure. The formulas for calculating evaporation derived by Dalton, Weilenmann, Stelling, de Heen, Schierbeck, Trabert, Stefan, etc., are quoted.

Ingham, W.
Statistics dealing with evaporation, rainfall, and delivery of streams in Devonshire. Transactions of the Devonshire Association for the Advancement of Science, 1901, **33**:500. Abstract in Proc. inst. civ. engin., ——, **150**:506.

Measurements of evaporation from a free water surface in a tank at Kennich, Devonshire, for the years 1897–1900, show an annual average amount of 20.88 inches, or 50.81 per cent of the rainfall. Records of rainfall on the Torquay watershed for 23 years are also given.

König, Friedrich.
Die Verteilung des Wassers über, auf und in der Erde, und die daraus sich ergebende Entstehung des Grundwassers und seiner Quellen mit einer Kritik der bisherigen Quellentheorien. Geschildert für Tiefbautechniker, technische Forst-, Montan- und Landwirtschaftslehranstalten, sowie zum Selbststudium. Jena. 1901. 7 vol.

A general discussion of the conditions favoring evaporation appears in vol. 4, p. 53–69. By modifying the Dalton formula he calculates the yearly rates of evaporation for different mean annual temperatures. The rates corresponding to 0°, 5°, 10°, 15°, 20°, and 25° C. would be 340, 720, 1,030, 1,650, 2,270, 3,500 millimeters. These agree with the amounts actually observed at Cumaná, Venezuela, 3,520 mm.; at Madeira, 2,030 mm.; at Sidney, 1,290 mm.; for Holland, 600–800 mm.; for the English coast, 900 mm.; for London, 650 mm.; and 800 mm. for East Scotland.

Manson, Marsden.
Features and water rights of Yuba River, Cal. In report of irrigation investigations in California prepared under the direction of Elwood Mead. Cal. exp. sta. bul., 1901, No. 100: 115–30.

A table of evaporation at Lake Fordyce (alt. 6,500 ft.) from Aug. 10–31, 1900, appears on p. 126. The daily average was 1/6 inch.

Müller-Erzbach, W.
Das Messen des Dampfdruckes durch Verdunstung. Sitzber. k. Akad. Wiss. (Vienna) math. naturw. Kl., 1901, **110**(pt. 2a):519–36.

The author concludes from his experiments that the vapor pressure of liquids may be determined with sufficient accuracy and more easily by evaporation than by manometric measurement.

Olmsted, Frank H.
Physical characteristics of Kern river, Cal. Water sup. and irr. papers, 1901, No. 46:25.

General statement of the losses due to evaporation and seepage.

Oppokow, E.
Das Verhalten des Grundwassers in der Stadt Neshin im Zusammenhange mit den meteorologischen Elementen. Zeits. Gewässerk., 1901, **4**:76–99.

Tables of rainfall, 1885–99, and evaporation, 1895–9, show an annual average for the former of 539 millimeters and for the latter of 379 millimeters.

Schuyler, James D.
Problems of water storage on torrential streams of southern California, as typified by Sweetwater and San Jacinto rivers. In report of irrigation investigations prepared under the direction of Elwood Mead. Calif. exp. sta. bul., 1901, No. 100:353–95.

The average annual rate of evaporation from Sweetwater Reservoir, from observations of several years, is 4.5 feet (p. 357).

Smythe, William E.
The irrigation problem of Honey Lake Basin, Cal. In report of irrigation investigations prepared unker the direction of Elwood Mead. Exp. sta. bul., 1901, No. 100:71–113.

The experiments of the California State Engineering Department, covering a period of five years, show the evaporation from Buena Vista, Kern, and Tulare lakes, which closely resemble Honey Lake, to be from 3.5 to 4.75 feet per year (p. 75).

Taihoku Meteorological Observatory.
Meteorological observations in Formosa, 1896–1901. Formosa. 1901.

The monthly evaporations at Taihoku, Taichu, Tainan, Taito, Koshun, Hokoto, and Keelung are given on p. 131–3. At Taihoku the monthly amount varies from 49.8 millimeters in February to 180.9 millimeters in July, and the annual average is 1266.2 millimeters. Tables of mean daily amounts and of daily maxima are also given.

Trimble, R. E.
See Carpenter, L. C., and R. E. Trimble.

U. S. Geological Survey.
Operations at river stations, 1900. Rpt. of the Division of Hydrography. Water sup. and irr. paper, 1901, No. 52:501.

Wallis, H. Sowerby, and Hugh Robert Mill.
Records of evaporation. Brit. rainf., 1901, (—):28–34.

Tables of evaporation for 1901 at nine stations, seven of which use standard tanks 6 feet square, with tables comparing evaporation throughout England, from 1888 to 1900. The average annual losses from the tank at Strathfield Turgiss, 18.03 inches for fourteen years (1870–83); from Miller's sand-protected evaporator at Lowestoft, 22.27 inches for twenty years (1878–97); from the tank at Camden Square, 15.19 inches for sixteen years (1885–1900); from Latham's floating atmometer at Croyden, 16.81 inches for fourteen years (1888–1901).

1902.

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Der Einfluss des Waldes auf die Verdunstung der Feuchtigkeit in seiner Umgegend. (Russian.) Lěsoprom. věst., Moscow, 1902, (4), **49**:882–3.

Abbassia Observatory.
Report on meteorological observations, 1900. Public Works Department of Egypt, Survey Department. Cairo. 1902.

Tables of hourly evaporation (Wild evaporometer) and daily totals for the year 1900, show an annual evaporation of 1778.7 millimeters.

Davis, Walter G.
Climate of the Argentine Republic compiled from observations made to the end of the year 1900. Buenos Aires. 1902.

Observations described in Davis, 1900, are continued on p. 83–90, with tables including results from 1886–1900.

Desenzano, Osservatorio Meteorologico.
Osservazioni meteorologiche. Comment. Ateneo, Brescia, 1902, (—): 421–26.

The total evaporation at Desenzano, at the south end of Lake Garda, for the year from September, 1901, to August, 1902, inclusive, was 688.9 millimeters, the monthly amounts varying from 14.0 millimeters in February to 131.9 millimeters in July.

Hungary.
Königliche Ungarische Reichsanstalt für Meteorologie und Erdmagnetismus, Jahrbuch, 1902, **32**:97.

The daily evaporation at O-Gyalla during 1902 was 1.4 millimeters.

Jaubert, Joseph.
Annales de l'observatoire municipal (Observatoire de Montsouris), 1902, **3**:137–41, 222–6, 301–3.

The Piche evaporometer was employed at Montsouris and at the Tour St. Jacques in Paris. The water was usually frozen in the winter months. At Montsouris the monthly amount varied from 40.7 millimeters in October to 148.0 millimeters in July, and at the Tour St. Jacques from 69.3 millimeters in October to 177.8 millimeters in July.

Lippincott, J. B.
Storage of water on King's river, Cal. Water sup. and irr. papers, 1902, No. 58:22–4, 81–2, 99.

Tabulation of the observations of evaporation at Kingsbury, Cal., reported by Hall (1886) and quoted by Grunsky (1901). Summary of measurements made in King's river canals in August and September, 1901, to determine the loss by seepage and evaporation.

Memmo, Osservatorio Meteorologico.
Osservazioni meteorologiche. Comment. Ateneo, Brescia, 1902, (—): 428–32.

The maximum observed monthly evaporation for the year, September, 1901, to August, 1902, was 57.7 millimeters in July, 1902. Records were not obtained during the winter months owing to the freezing of the water in the instruments. The type of instrument is not indicated.

Okada, T.
Ueber die Evaporationskraft des Föhn. Met. Zeits., 1902, **19**:339–42.

In Japan the foehn is usually a northwest wind of considerable violence and greatly accelerates the rate of evaporation from water in a small copper dish freely exposed in an open place. Observations are tabulated.

Ridgway, C. B.
Experiments in evaporation. Wyoming exp. sta. bul., No. 52. Laramie. 1902.

For these experiments a tank was used having a perforated bottom and containing soil supplied with water from a larger reservoir directly below, the whole apparatus being sunk in the ground. Water was supplied to the reservoir through a tube leading from the surface of the ground. A float in the tube actuated a pointer moving over a graduated scale which reached above the ground, and showed the variations of the water level. The rate of evaporation from soil with the water level maintained 6 inches below the soil surface, was 95 per cent of that from a free water surface in the evaporation tank. With the water level 12, 18, and 22 inches below the soil surface, the evaporation was 70, 45, and 35 per cent respectively. Loosening the soil once a week to the depth of 2 inches diminished the evaporation 10 per cent; to the depth of 4 inches, 23 per cent; and to 6 inches, 45 per cent.

Salo. Osservatorio Meteorologico.
Osservazioni meteorologiche. Comment. Ateneo, Brescia, 1902, (—): 434–7.

The average daily evaporation at Salò, on Lake Garda, for the year September, 1901, to August, 1902, inclusive was 2 2 millimeters.

Schwalbe, G.
Ueber die Darstellung des jährliches Ganges der Verdunstung. Met. Zeits., 1902, **19**:49–59.

The following formula for calculating evaporation is presented: $v'=A'(t-t')$, where $v'=$ calculated evaporation, $A'=$ a constant embracing the wind factor and varying from 0.46 to 1.2 at different places, $(t-t')=$ the difference between the readings of the wet- and dry-bulb thermometers. This formula was tested at 19 stations in Russia. Curves comparing the observed and calculated values, v and v', at several places, lead to the conclusions: (1) $(t-t')$ is a relative measure of the evaporation. (2) The yearly march of $(t-t')$ and v both depend on the sun's declination and in the same way.

There is a concise discussion of the formulas developed by Dalton, Stefan, Weilenmann, Stelling, de Heen, Ule, Krebs, Schierbeck, and Trabert, and a uniform notation is employed in writing them.

Taylor. L. H.
Water storage in the Truckee Basin, California-Nevada. Water sup. and irr. paper, 1902, No. 68: 34–6.

Monthly evaporation observed from a tank floated on the surface of Lake Tahoe, Cal., from May, 1900, to December, 1901, together with calculations of the inflow and outflow, served to determine the reduction of the lake level, which corresponded very closely with the reduction as observed by means of a fixed gage. The results of evaporation at Reno, Nev., during 1894, from a somewhat smaller tank sunk in the ground and surrounded with moist soil are tabulated.

U. S. Department of Agriculture, Office of Experiment Stations.
Report on irrigation investigations for 1901. Off. Exp. Sta., 1902, Bul. 119.

On p. 92, 294, 334–6, and 353 are records of evaporation secured by agents of the Office of Experiment Stations at various places in Arizona, Colorado, Montana, Nevada, New Mexico, New Jersey, Utah, Washington, and Wyoming.

Wallis, H. Sowerby, and Hugh Robert Mill.
Records of evaporation. Brit. Rainf., 1902, (—): 49–53.

Tables similar to those of the preceding years. For succeeding records see Mill, Hugh Robert.

1903.

Barus, Carl.
Absence of electrification in cases of sudden condensation and of sudden evaporation. Phys. rev., 1903, **16**:384.

Ordinary evaporation and condensation have long been known to be unaccompanied by electrification, but when a mass of water is suddenly shattered as in jets, there is a marked production of electricity. The question arose, therefore, as to whether the absence of an electric effect in ordinary evaporation and condensation cases was not due to the fact that the charges vanish too quickly to be noticeable. Further experiments, however, with sudden condensation and evaporation showed an absence of electrification.

Batavia, Koninklijk magnetisch en meteorologisch Observatorium.
Results of meteorological observations made at the experiment station "Oost-Java" at Pasoeroean, during the year 1902. Natkdg. Tijdsch. Ned. Ind., 1903, **62**: 267–72.

Includes observations on evaporation.

Bok, Oscar.
Verdunstungsmessungen nebst Untersuchungen über die Verdunstungshöhen an den forstlich-meteorologischen Stationen in Elsass-Lothringen. Beitr. Geophysik, Leipsic, 1903, **6**:1–16.

Desenzano, Osservatorio Meteorologico.
Meteorologia. Comment. Ateneo, Brescia, 1903, (—):139–43.

The monthly evaporation at Desenzano for the year from September, 1902, to August, 1903, inclusive, varied from 14.70 millimeters in January to 113.80 millimeters in August.

Hall, A. D.
The soil. An introduction to the scientific study of the growth of crops. New York. 1903.

Discusses (p. 120–2) the amount of heat required for evaporation, with tables and curves of soil temperatures showing the cooling effect of the evaporation of soil moisture. The advantage of cultivation of the surface soil in decreasing evaporation, owing to the breaking of the capillary channels, is pointed out (p. 92–101) and King's experiments with glass cylinders full of fine sand are described.

Hann, J.
J. R. Sutton—Experimente über Verdunstung. Met. Zeits., 1903, **20**:517–8.

Discusses the experiments of Sutton (1903) and Latham (1897–1904), on the influence of different methods of measuring evaporation, and considers: (1) the size of the evaporator, (2) the capillary attraction of the walls, (3) the enamelling of the outside surface, (4) the material of the instrument, (5) the influence of relative humidity and wind velocity, (6) the probability that the influence of the surface temperature of the water has been over estimated.

Jaubert, Joseph.
Notice sur l'évaporomètre de Montsouris. Ann. obs. Montsouris, 1903, **4**:30–2.

Describes an instrument for measuring evaporation from soil. It consists of a sheet iron box, 30 by 30 by 30 centimeters, filled with soil in which grass is allowed to grow. The variations in weight of the soil are registered automatically by a steel-yard balance on which the box rests. The whole is placed in the ground, so that its upper surface is on a level with that of the surrounding soil. The excess water in the box may be drawn off by means of a pipe soldered to the bottom of the box. The author believes the disadvantage of this method of determining soil moisture to lie in the fact that the soil in the box dries out more rapidly than natural soil, the latter being able to draw new supplies of moisture from lower layers.

Jelinek, Carl.
Jelinek's Psychrometer-Tafeln erweitert und vermehrt von J. Hann, neu herausgegeben und mit Hygrometer-Tafeln versehen von J. M. Pernter. Fünfte erweiterte Auflage. Leipsic. 1903.

Lindgren, Waldemar.
The water resources of Molokai, T. H. Water sup. and irr. paper, 1903, No. 79:48.

The probable amount of evaporation was calculated from the rainfall and runoff for separate areas.

Memmo, Osservatorio Meteorologico.
Meteorologia. Comment. Ateneo, Brescia, 1903, (—):144–7.

The average daily amount [of evaporation] for the year was 2.4 millimeters.

Mill, Hugh Robert.
Records of evaporation. Brit. rainf., 1903, (—):38–41.

The evaporation for the year (11 stations) was 17.7 inches. Latham's table of evaporation at Croydon appears as usual. The water in his 5-inch exposed vessel evaporated twice as much during the winter and spring, and in the summer only about 1.5 times as much as that in the 12-inch floating evaporator. A second table by Latham shows the amount of percolation at several stations.

Müller-Erzbach, W.
Der Dampfdruck des Wasserdampfes nach der Verdampfungsgeschwindigkeit. Sitzber. k. Akad. Wiss. (Vienna) math. naturw. Kl., 1903, **112**(pt. 2a):615–20.

The vapor pressures derived from the rate of evaporation from tubes are found to agree closely with those given by Regnault.

Naples. R. Osservatorio di Capodimonte.
Osservazioni meteoriche. Rend. soc. sci., 1903, **9**(3d ser.):16, 65, 98, 146, 168, 184, 219, 261–4, 307.

The monthly evaporation for 1903 varied from 38.1 millimeters in January to 112.3 millimeters in September, with the rainfall varying from zero in August to 196.4 millimeters in December.

Okada, T.
Vergleichende Messungen der Verdunstung des Meerwassers und des Süsswassers. Met. Zeits., 1903, **20**:380–4.

Under similar conditions, the ratio between the mean daily evaporation from salt and fresh water at Azino, Japan, was 0.950, and nearly constant for all seasons. Tables show the daily maxima and the monthly means from January, 1895, to December, 1901. The most important elements influencing evaporation are thought to be air temperature and insolation. Devises the formula

$$D = ax + by,$$

Where $D =$ fresh water minus sea water,
$x =$ temperature of the air,
$y =$ daily duration of sunshine,
$a, b, =$ constants, $=$ 0.079 and 0.076, respectively, at Azino, in western Japan.

Oppokow, E.
Zur Frage der vieljährigen Abflusschwankungen in den Bassins grosser Flüsse, im Zusammenhang mit dem Gang der meteorologischen Elemente. Vergleichende Untersuchung des Abflusses im Gebiete des Dnjepr oberhalb der Stadt Kijew und der oberen Elbe in Böhmen. Zeits. Gewässerk., 1903, **5**:340–65.

Includes curves of rainfall, evaporation, and runoff from 1874–94, with a table of the yearly amounts from 1875–94 on the Elbe in Bohemia.

Perman, D. E. P.
The evaporation of water in a current of air. Communicated by Prof. E. H. Griffiths, F. R. S., to the Royal Society, February 19, 1903. Nature, 1903, (—):477.

Rafter, George W.
The relation of rainfall to runoff. Water sup. and irr. paper, 1903, No. 80:30–43.

Papers by Vermeule (1893 and 1900) are abstracted. Computes the evaporation from the Muskingum basin, N. Y. (O?). Definition and tables of so-called "negative evaporation" are added.

Russell, H. C.
Results of rain, river, and evaporation observations made in New South Wales during 1900. Sydney. 1903.

Salo, Osservatorio Meteorologico.
Meteorologia. Comment. Ateneo, Brescia, 1903, (—):148–55.

The average daily evaporation from September, 1902, to August, 1903, inclusive, was 2.4 millimeters.

Sutton, J. R.
Results of some experiments on the rate of evaporation. Trans. So. African phil. soc., 1903, **14**, pt. 1. Review in Met. Zeit., 1903, **20**: 517–8. Reprinted, 23 p., 8vo.

Compares the evaporation from various containers and from a Piche tube. Finds that the latter instrument is especially susceptible to the influence of the wind. The experiments of 1900 lead to the conclusions: (1) The humidity of the air exerts the most powerful influence on the rate of evaporation. (2) A wind factor is needed. (3) The great perturbing influence attributed to the temperature of the water has not been wholly confirmed.

Experiments with colored glass over the evaporating surface show that for each 1° excess of temperature due to such influence the depth of annual evaporation will increase by 1.5 inches.

Ule, Willi.
Niederschlag und Abfluss in Mitteleuropa. Forschungen zur Deutschen Landes- und Volkskunde, Stuttgart, 1903, **14**:435–516.

In the upper Saal valley the average rainfall for the 20 years, 1882–1901, was 615 millimeters, and the average run-off 170 millimeters. The run-off is 27.5 per cent, the evaporation is estimated at 51.5 per cent, and vegetation uses 21 per cent. This would make the average annual evaporation for this region about 316.7 millimeters.

Vlasov, V. A.
Observations météorologiques de la station du champ d'expérience de Poltava, 1886–1900. Vol. II: Dépôts atmosphèriques, évaporation, etc. (Russian and french.) Poltava. 1903. 633 p.

1904.

Batavia, Koninklijk magnetisch en meteorologisch Observatorium.
Results of meteorological observations made at the Experiment station "Oost-Java" at Pasuruan, during the year 1902. Natkdg. Tijdsch. Ned. Ind., 1904, **63**:220–5.

Includes observations on evaporation.

Black, William Galt.
Observations of rain, dust, and evaporation, Edinburgh, 1903. Symons's met. mag., 1904, **39**:29.

Bologna, Osservatorio della R. Università.
Osservazioni meteorologiche fatte durante l'anno, 1903. Mem. accad. sci., Bologna, 1904, **1**, (6th ser.):325–53.

The total evaporation for 1903 was 1234.5 millimeters, the rainfall was 547.9 millimeters.

Burgerstein.
Die Transpiration der Pflanzen. Jena. 1904.

An exhaustive and critical bibliography of works dealing with transpiration from plants.

Curtis, Richard R.
Water-vapor. Quart. jour. roy. met. soc., 1904, **30**:193–209.

A general survey of the physics of evaporation with a statement of the relative amounts of rainfall and evaporation in the British Isles.

Desenzano, Osservatorio Meteorologico.
Osservazioni fatte nel 1903. Comment. Ateneo, Brescia, 1904, (—): 185–9.

The total evaporation for the year September, 1903, to August, 1904, inclusive, was 852.7 millimeters.

Gibbs, L.
Evaporation from the land. Quart. jour. roy. met. soc., 1904, **30**: 39–40.

Discusses literally and graphically the effect of the duration and character of the rainfall on the evaporation.

Hungary.
Königliche Ungarische Reichsanstalt für Meteorologie und Erdmagnetismus. Jahrbuch, 1904, **34**:218, 219.

At Nagytagyos the total evaporation for 1904 was 852.4 millimeters, and at Temesvár 494.4 millimeters.

Jaubert, Joseph.
Observatoire Municipal [de Paris], (Observatoire de Montsouris). Annales, 1904, **4**:19, 94–6, 220–4, 383–7.

At Montsouris the monthly totals varied between 92.6 millimeters in October to 173.5 millimeters in July; at the Tour St. Jacques they varied between 41.4 millimeters in October to 118.1 millimeters in July. No records are given for the winter months.

Kimball, Herbert Harvey.
Evaporation observations in the United States. Mo. weather rev., 1904, **32**:556–9. Reprinted U. S. Dept. Agric., Weather Bur., No. 327. Washington. 1905.

Quotes Rafter's (1903) computations of evaporation from the run-off and rainfall over a watershed for different localities during long periods. Two other methods of determining evaporation are considered as of more practical importance—by direct measurements from properly exposed water surfaces, and by computations based upon the temperature of the water surface and the values of certain meteorological elements. The formulas of T. Russell, Fitzgerald, Carpenter and Stelling are compared and discussed. An account of experiments made by the U. S. Geological Survey in 1888 in the arid regions is followed by a table of measured annual evaporations at various stations, for the purpose of checking Russell's computed values. Reproduces T. Russell's chart of evaporation over the United States.

Krebs, Wilhelm.
Ueber Verdunstungsmessungen mit dem Doppelthermometer für klimatologische und hydrographische Zwecke. Verhdl. Deut. phys. Gesellsch., 1904, **6**:278–9.

See Krebs, 1905.

Luedecke, Carl.
Ueber die Grösse der Bodenverdunstung bei verschiedenen Tiefe des Grundwasserspiegels. Kulturtechniker, Breslau, 1904, **7**:195–8.

Memmo, Osservatorio Meteorologico.
Osservazioni fatte nel 1903. Comment. Ateneo, Brescia, 1904, (—): 190–7.

The total evaporation for the year from September, 1903, to August, 1904, inclusive, was 390.1 centimeters.

Mill, Hugh Robert.
Records of evaporation. Brit. rainf., 1904, **44**:46–51.

Gives observations from the same stations as in 1903. The results obtained at the eleven stations average 17.32 inches, with a rainfall of 26.49 inches.

Mitscherlich, Alfred.
Ein Verdunstungsmesser. Landw. Vers. Stat., 1904, **60**:63–72, and 1904, **61**:320.

The author considers measurements of evaporation from open vessels of little value for agricultural purposes, since the instrument usually can not be placed in the open on account of rain, and because the edge of the vessel always protects the surface of the water from the full action of the wind. He devises an instrument essentially that described by Babinet, 1848, and Marié-Davy, 1869. The evaporation per square centimeter indicated by this instrument was to that from a free water surface as 1.94 to 1 for a large cylinder, and 1.29 to 1 for a smaller one. This apparatus exposed in the writer's experimental field at Kutschlau near Schwiebus, Brandenburg, from April 5 to July 20, 1903, indicated an evaporation of 130.14 millimeters, while the rainfall was 205.50 millimeters. At Kiel the evaporation was only about one-half to one-third that at Kutschlau and the rainfall was considerably greater. Recommends this evaporometer as a substitute for the registering hair hygrometer.

Naples. R. Osservatorio di Capodimonte.
Osservazioni meteoriche. Rend. accad. sci., fis. math. Sez., Naples, 1904, **10** (3d ser.): 38, 78, 180–1, 267–9, 323–6, 400.

The monthly amounts of evaporation in 1904 varied from 46.9 millimeters in January to 134.6 millimeters in July. The rainfall varied from 17.6 millimeters in July to 157.1 millimeters in October.

Okada, T.
Evaporation in Japan. Bul. cent. met. obs., Japan, 1904, No. 1:31.

Evaporation is observed at fifty stations in Japan. The evaporometer is a cylindrical, zinc-lined copper vessel, 20 centimeters in diameter and 10 centimeters deep. A table of comparative observations in sun and shade for 1891–1893 shows that the difference is greatest in summer and least in winter. Tables of the mean daily and the monthly evaporation for the fifty stations show minima in January and June and a maximum in August. Geographically the annual evaporation in Japan decreases from 1,910 millimeters at Koshun in the southwest, to 734 millimeters at Kushiro in the northeast. The annual rainfall usually exceeds the evaporation. The monthly evaporation at twelve stations is shown graphically and a chart presents the distribution of evaporation over Japan.

Oppokow, E.
Zur Frage der vieljährigen Abflussschwankungen in den Bassins grosser Flüsse, im Zusammenhang mit dem Gang der meteorologischen Elemente. Vergleichende Untersuchung der mittleren Abflusswerthe im Flussbecken des oberen Dnjepr und der oberen Elbe in Zusammenhang mit der Frage über Charakter und Grenzen des Einflussen der Lokalitäten eines Flussbeckens auf den Abfluss. Zeits. Gewässerk., 1904, **6**:1–23.

The percentage of the rainfall evaporating from a bare moor soil was found to be 29.3, and the run-off 59 per cent. For a mixture of moor soil and sand lying over moor soil the figures were 25.5 and 63 per cent. For moor soil covered with coarse sand, 11.6 and 87 per cent.

Oppokow, E.
Zur Frage der vieljährigen Abflussschwankungen in den Bassins grosser Flüsse, im Zusammenhang mit dem Gang der meteorologischen Elementen. Ueber Aufspeicherung und Consum der Feuchtigkeit im Bassin des oberen Dnjepr. Zeits. Gewässerk., 1904, **6**: 156–75.

The evaporation and seepage are calculated from the rainfall and run-off. Tables and curves are presented for the basin of the Dnieper, and tables from R. Scheck and Ule for the basin of the Saal, 1872–1901. (See Ule, 1903.)

Oppokow, E.
Einige Daten über die Schwankungen des Abflusses und der absoluten Verdunstung in den grossen Flussbassins im Zusammenhang mit den Klimaschwankungen und dem Einfluss der Boden- und Pflanzen-Bedeckung. (Russian.) Pédologie, St. Petersburg, 1904, **6**:182–9.

Russell, H. C.
Results of rain, river, and evaporation observations made in New South Wales during 1901–2. Sydney. 1904.

Salo, Osservatorio Meteorologico.
Osservazioni fatte nel 1903. Comment. Ateneo, Brescia, 1904, (—): 198–204.

The average daily amount for the year September, 1903, to August, 1904, inclusive, was 2.7 millimeters, ranging between 0.6 millimeters in December, and 6.4 millimeters in July.

Sutton, J. R.
On certain relationships between the diurnal curves of barometric pressure and vapor tension at Kenilworth (Kimberley), South Africa. Quart. jour. roy. met. soc., 1904, **30**:41–55.

A modern discussion of the physics of evaporation with consideration of the theories proposed by Dalton, Lamont, and Deluc. Concludes that changes in the barometer may be due to changes in the vapor pressure rather than to those of temperature.

Sutton, J. R.
Results of some further observations upon the rate of evaporation. Rpt. So. African assoc. adv. sci., Johannesburg. 1904.

Experiments from 1900–04 with a Piche atmometer and the evaporometer described in Sutton, 1903, shows the highest rate from the Piche in the daytime, but not at night. It is concluded that this may be due to the stronger winds of the day, and possibly to the greater range of the temperature of the water in the Piche. Quotes similar results by Shaw. In summer the ratios between the instruments are more nearly equal than in winter. A mathematical discussion seeks to determine the relation of the different factors which influence the evaporation rate.

1905.

Abbe, Cleveland.
The Piche evaporometer. Mo. weather rev., 1905, **33**:253–5.

Summarizes Russel's (1888) results. Describes the Piche atmometer, and gives a table showing the effect of wind upon the rate of evaporation. "The true method of treating evaporometers of all kinds within instrument shelters is to consider them as integrating hygrometers. For such exposures the total evaporation during an hour or a day is a simple

result of the temperature, the wind, and the dryness. Knowing the two former and the measured evaporation, we may compute the average dryness. This average dryness is a much more important datum to the meteorologist than is the measured evaporation to the climatologist. Of course, hydraulic and irrigating engineers need to know the loss of water by evaporation, but in nature this is so mixed up with seepage, leakage, and consumption by animals and plants, that our meteorological data are of comparatively of little importance. For the agricultural engineer the lysimeter and Symons' evaporometer, 6 feet square, are essential apparatus, but for the meteorologist an integrating hygrometer, such as the Piche evaporometer really is, is the important instrument."

Bacon, Arthur A.
The equilibrium pressure of a vapor at a curved surface. Phys. rev., 1905, **20**:1-9.

Discussion of the laws regulating the equilibrium between evaporation and condensation at the surface of a liquid in capillary tubes, with a résumé of the history of the subject.

Bentley, Richard.
The growth of instrumental meteorology. Quart. jour. roy. met. soc., 1905, **31**:173-92.

Two paragraphs on evaporometers occur on p. 185 and 196. Richard's (1898) self-recording evaporation gage and Symons's evaporation tank are described.

Boname, P.
Meteorologie. Rap. ann. sta. agron. Mauritius, 1905, (—):1-10. Abstract in Exp. sta. rec., 1906, **18**:311.

The annual evaporation in Mauritius for 1905 was 376.2 millimeters, with a rainfall of 2,410.2 millimeters. This is said to have been an unusually wet year.

Brückner, Eduard.
Die Bilanz des Kreislaufs des Wassers auf der Erde. Geogr. Zeits., 1905, **11**:436-45. Abstract in Arch. sci. phys. et nat., 1905, **20**: 427-30.

General survey of the evaporation measurements made in different parts of the earth, and the part played by evaporation in the cycle of the waters of the earth.

Day, W. H.
Experiments on evaporation and transpiration. Ann. rpt. Ontario agr. coll. and expt. farm, 1905, **31**:40-2. Abstract, Exp. sta. rec., **17**:841.

Studies on the amount of water required by wheat, barley, oats, and peas show that barley requires the least water for growth and peas the most. An attempt to use the Piche evaporometer for purposes of comparison showed that several instruments "would not record the same amount under the same conditions nor even amounts bearing constant ratios to one another."

Desenzano, Osservatorio Meteorologico.
Osservazioni fatte nel 1904. Comment. Ateneo, Brescia, 1905, (—): 157-61.

The monthly evaporation for the year from September, 1904, to August, 1905, inclusive, varied from zero in December, and 1.2 millimeter in January to 104.2 millimeters in August.

Fortier, Samuel.
Loss of water by evaporation. Engin. rec., 1905, **51**:430.

Very comprehensive experiments in evaporation, undertaken by the Office of Exp. Stas. and the State of California, show that the amount of evaporation is largely dependant on the temperature of the water. The rate of evaporation from cultivated soil seems to depend on the amount of soil moisture, on the temperature and physical character of the soil, the condition of the atmosphere, the wind, etc. Experiments in irrigation indicate that surface flooding is most wasteful and that furrows 12 inches deep conserve much more moisture than do shallow furrows of 3 inches. The average evaporation under each method, during September and October, was 6428, 5581, and 4811 cubic feet per acre, respectively.

Gessert, F.
Die Grundwasserverdunstung in Steppen, speciell Südwest-afrika. Zeits. Kolonialpol., Berlin, 1905, **7**:301. Translated by L. Laloy in Bul. soc. géog., 1905, **12**:53-5.

The cause of the high evaporation rate from the steppe soils of Southwest Africa are given as: (1) circulation of air through the porous soils due to differences in temperature. (2) destruction of forests which formerly covered the soil, by erosion and periodic burning. (3) strong capillary action.

Evaporation is shown to produce an increase in the salt content of the upper layers of the soil. The amount of evaporation is estimated as probably more than the runoff of streams. The remedies for excessive evaporation are believed to lie in changing evaporation from the depths to the surface, either by pumps in some particular cases, or in a more general manner by reestablishing a plant cover such as dates and cactus.

Hall, A. D.
The Book of the Rothamsted Experiments. London. 1905. xl, 294 p.

Results of percolation experiments, averaged for each month for 34 years (1871-1904), appear on p. 22-3. The average annual rainfall was 28.98 inches, of which 15.8 inches was evaporated or retained by the soil in a 20-inch gage, 14.25 inches in a 40-inch gage, and 15.19 inches in a 60-inch gage.

Hungary.
Königliche Ungarische Reichsanstalt für Meteorologie und Erdmagnetismus. Jahrbuch, 1905, **35**:224, 225.

The monthly evaporation in 1905 at Temesvár varied from 8.2 millimeters in January to 81.3 millimeters in July, with a total for the year of 430.4 millimeters. At Nagytagyos the monthly amount varied from 6.7 millimeters in November to 72.9 millimeters in August, with a total of 331.3 millimeters.

Krebs, Wilhelm.
Ueber Verdunstungsmessungen mit dem Doppelthermometer für klimatologische und hydrographische Zwecke. Met. Zeits., 1905, **22**:211-21.

Measurements of evaporation from tanks placed in the waters of Mansfelder Lake in June, 1894, in Platten Lake, in October, 1894, and in White Lake in the High Vosges in July, 1903, are compared with the readings of the wet- and dry-bulb thermometers.

Memmo, Osservatorio Meteorologico.
Osservazioni fatte nel 1904. Comment. Ateneo, 1905, (—): 162-5.

The total evaporation for the year, from September, 1904, to August, 1905, inclusive, was 344.1 millimeters. The water in the instrument was frozen during the three winter months.

Mill, Hugh Robert.
Relation of evaporation from a water surface to other meteorological phenomena in 1905, at Camden Square. Brit. rainf., 1905, **43**:35-9.

Curves of the evaporation, temperature, etc., at Camden Square, are presented. When the curve of the rate of evaporation was below the average for the year it followed that of the mean temperature; when it was above the average it followed those of the duration of sunshine and the black-bulb temperature. The wind appeared to have little effect at any time.

Mill, Hugh Robert.
Records of evaporation. Brit. rainf., 1905, **45**:40-4.

Evaporation for the year, averaged from records at eleven stations in the British Isles, was 17.72 inches, with a rainfall of 25.35 inches.

Mitscherlich, Alfred.
Bodenkunde für Land- und Forstwirte. Berlin. 1905.

In section 35, p. 204-13, the author discusses evaporation from soil. He cites Eser, Ebermayer, Meister, Vogel, and Wollny on the influence of the size of the soil particles, the kind of soil, the vegetation, the inclination of the surface, the depth of the ground water and the capillary power of the soil, tillage of the soil, and mulches. Additional tables on p. 300-3 compare evaporation from free water surfaces with that from various kinds of soil and vegetation.

Salo, Osservatorio Meteorologico.
Osservazioni fatte nel 1904. Comment. Ateneo, Brescia, 1905, (—): 168-71.

The average daily evaporation varied from apparently zero in February and March and 0.7 millimeter in December to 4.3 millimeters in July.

Shchusev, S. [V].
La méthod de détermination de l'humidité des sols. (Russian.) Pédologie, St. Petersburg, 1905, **7**:63-6.

Shipchinskii, V. V.
Un cas d'évaporation. (Russian.) Met. Vest., 1905, **15**:87-95.

Slovinskii, — —.
[Meteorological observations for the year 1905 at the Ploti agricultural experiment station.]
Godichnuiĭ Otchet Ploty. Selsk. Khoz. Opuitn. Stantziĭ., 1905, **11**:1-24, 121-4. Abstract, Exp. sta. rec., 1906, **18**:311.

Observations on evaporation, in connection with other meteorological data.

Strachan, Richard.
On percolation gages. Horological journal, London, 1905, **47**:115-7.

Several well-known percolation gages and those used at Rothamsted are described; also a self-recording apparatus designed and constructed by Messrs. Richard Frères.

Strachan, Richard.
On evaporation gages. Horological journal, London, 1905, **47**:129-34, 157-61; 1905, **48**:19-24, 40-5, 50-4.

General discussion of various classes of evaporometers, with detailed historical and bibliographical survey of examples of all kinds, and some treatment of evaporation from a mathematical point of view.

Strachan, Richard.
Measurement of evaporation. Quart. jour. roy. met. soc, 1905, **31**: 277-84.

Evaporation (15.04 inches) as calculated from the meteorological data for 1898 obtained at the Royal Observatory, Greenwich, is compared with the observed evaporation at Camdem Square (15.16 inches) and at Rothamsted (15.67 inches). Discusses Pole's formula (see Latham, 1900), and two proposed by R. J. Mann (1871), all of which are regarded as inapplicable. Abbe and Fitzgerald are quoted, and T. Russell's experiments on the influence of the wind on a Piche tube. "The necessity, however, is made apparent of improving the accuracy of evaporometers, and of the importance of achieving a standard instrument of this class." The formula used at the Royal Observatory for calculating evaporation is as follows: The depth of water evaporated in a month $= 13.59\ (V - v)\ ab$, where $V =$ vapor pressure at the temperature of the air, $v =$ vapor pressure at the dew-point, $a =$ mean daily temperature of the evaporating water, and $b =$ coefficient of expansion of water.

Transeau, Edgar N.
Forest centers of eastern America. Amer. nat., 1905, **39**.875-89. See also Ann. rpt. Mich. acad. sci., 1905.

Draws lines of equal ratios between rainfall and evaporation in eastern North America, Russell's (1888) chart being used as the basis for the evaporation data. Finds that these lines indicate "climatic centers" corresponding in general with the centers of plant distribution which latter are resultants of temperature, relative humidity, wind velocity, and rainfall.

Wada, Y.
Japanese meteorological service in Korea and Manchuria. (Translated by Dr. S. Tetsu Tamura.) Mo. weather rev., 1905, **33**:397-9.

At Chemulpo Observatory the total evaporation from an 8-inch evaporometer for the year June, 1904, to June, 1905, was 1254.8 millimeters. The monthly rates varied between 175.6 millimeters in June, 1905, and 59.0 millimeters in January, 1905. The total rainfall for the year was 707.6 millimeters.

1906.

Alfaro, Anastasio.
Costa Rican climatological data. Mo. weather rev., 1906, **34**:60, 305.

The total evaporation for January, 1906, was 62.5 inches, and for March, 67.9 inches.

Boulatovitch, M.
Meteorological observations for the year 1906 at the Ploti Agricultural Station. Godichnuiĭ Otchet Ploty. Selsk. Khoz. Opuitn. Stantziĭ, 1906, **12**:1-34, 229-34. Abstract, Exp. sta. rec., 1907, **19**: 616.

Evaporation for the year is given as 27.56 inches, the mean of 12 years being 32.78 inches.

Day, W. H.
Evaporation. Ann. rpt. Ontario agr. coll. and exp. farm, 1906, **32**: 31, 32. Abstract, Exp. sta. rec., 1907, **19**:11.

Observations of evaporation from a reservoir during the six months, June to November, showed a loss of 37.69 inches, or about 10 inches more than the mean annual rainfall for this place.

Fritsche, Richard.
Niederschlag, Abfluss und Verdunstung auf den Landflächen der Erde. Inaug. Diss. Halle-Wittenberg. Halle. 55 p. 8vo. Zeits. Gewässerk., 1906, **7**:321-70. Reviews, Naturw. Rundschau, 1907, **22**:111; Petermann's Mitteil., 1907, **53**:16 (Literaturbericht); Exp. sta. rec., 1908, **20**:114.

General estimates of annual rainfall, run-off, and evaporation on the land surfaces of the globe, revised from Murray (1887), and Brückner (Met. Zeits., 1887, **4**:[63]), and gives a table of evaporation according to latitude. (See also Brückner, 1908.)

Ginestous, C.
Meteorology of Tunis, winter of 1905-6. Bul. dir. agr. et com., Tunis, 1906, **10**:114-28. Abstract, Exp. sta. rec., 1906, **18**:10.

Sumarizes observations on pressure, temperature, humidity, rainfall, evaporation, etc., at a large number of stations in different parts of Tunis.

Hann, Julius.
Täglicher und jährlicher Gang der Verdunstung in Südindien. Met. Zeits., 1906, **23**:428-9.

Describes some experiments carried on at Trivandrum from 1857 to 1863 by John Allen Brown. Two evaporators, having exposed surfaces of 100 square inches, were filled with sea water, and placed, one in the shade, though exposed to wind, the other in the sun. The evaporation maxima fell in March and September, the minima in June, July, and November. The table of mean daily evaporation gives the annual amounts of 1032.36 millimeters in the shade, and 2523.94 millimeters in the sun.

Henry, Alfred J.
Salton Sea and the rainfall of the Southwest. Mo. weather rev., 1906, **34**:557-9.

Shows that the Salton Sea could not effect the rainfall of the Southwest.

[*To be continued.*]

PHOTOGRAPHING THE LEONIDS OF NOVEMBER, 1909.

To encourage the photographing of the Leonids under favorable atmospheric conditions the Treptow Sternwarte near Berlin, announces the following prizes which it offers:

First prize.—A telescope for amateurs, constructed by G. and S. Merz, Munich, according to a design by Dr. F. S. Archenhold. Mounting is equatorial and various eyepieces are furnished with it. Value = M. 125.00.

Second prize.—Six bound volumes of the illustrated astronomical fortnightly, "Das Weltall." Value = M. 84.00.

Third prize. A complete set of the 21 extra numbers of the "Weltall" comprising the lectures and addresses published by the Treptow Observatory. Value = M. 30.50.

Conditions of the competition.

1. The photographs must be made from a balloon, during the time from November 13 to 16, 1909.
2. The competition is open to the citizens of all nations.
3. The papers and negatives offered in competition are to be signed by a Motto only, and are to be accompanied by a sealed envelope containing the correct address of the contestant, the appropriate motto only to be written on the outside of this envelope.
4. The original negatives, developed and fixed, must be submitted in competition, accompanied by the following data:
   a. Place, date, and hour of the exposure.
   b. Name of the balloon.
   c. Altitude of the balloon.
   d. Name of the constellation in which the meteors were observed [photographed].
   e. Description of the camera and the lens, giving also its focal length and the aperture employed.
   f. Length of the exposure.
5. The original negatives awarded prizes by the three judges, to be named later, together with all rights of publication, become the property of the illustrated periodical "Weltall," published by the Treptow Observatory, Treptow-Berlin, Germany.
6. The last date for receiving photographs in competition is January 1, 1910.
7. The results of the competition will be published in "Das Weltall."

All papers and packages should be addressed,

Herrn Direktor Dr. F. S. Archenhold,
Treptow Sternwarte,
Treptow bei Berlin, Germany.

Directions and hints for photographing meteor showers, etc, may be found in "Das Weltall," 1st Year, No. 3, and all further details or advice will be willingly given by the Director of the Treptow Observatory at the above address.

HIGHEST BALLOON ASCENSION IN NORTH AMERICA[1].

By Prof. A. L. ROTCH, Blue Hill Observatory, Mass.

Although a large number of *ballons-sondes* were dispatched from St. Louis in 1904-7 under the direction of the writer[2], none had been employed in the eastern States until last year. In May and July, 1908, four *ballons-sondes* were launched from Pittsfield, Mass., with special precautions to limit the time they remained in the air and so prevent them from drifting out to sea with the upper westerly wind. Three of the registering instruments have been returned to the Blue Hill Observatory with good records. The first instrument, sent up on May 7, was not found for 10 months and the record, forming the subject of the present article, is very interesting, because it gives complete temperature data from the ground up to 17,700 meters (11 miles). This is 650 meters higher than the highest ascension from St. Louis.

On May 7, 1908, a general storm prevailed, so that the balloon, traveling from the east, was soon lost in the clouds and its subsequent drift could not be followed; but the resultant course was 59 miles from the southwest, as determined by the place where the instrument fell 2 hours later. At the ground the temperature was 4.5° C., and this decreased as the balloon rose to the base of the clouds, which itself was considerably warmer than the underlying air. Above the clouds the temperature continued to fall with increasing rapidity up to a height of 12,500 meters (7.7 miles) where the minimum of —54.5° C. was registered. Here the great warm stratum was penetrated farther than ever before in this country, namely, to the height of 17,700 meters (11.0 miles) where the temperature was —46.5° C. An increase of 8.9° C. occurred, however, in the first 3,000 meters, for above 15,500 meters nearly isothermal conditions prevailed, confirming the belief of Teisserenc de Bort that what he calls the "stratosphere" is composed of a lower inverting layer with isothermal conditions above extending to an unknown height.

In an ascension last November in Belgium the relatively warm stratum was found to extend from 12,900 meters (8.0 miles) to the enormous height of 29,000 meters (18.0 miles), where there was still no indication of its diminution.

TORNADOES IN OKLAHOMA.

On May 29, 1909, at about 4:30 p. m., two straight winds from about west and southwest respectively converged upon Key West, Lincoln County, and are reported to have there combined in a tornado of some intensity which traveled northeastward, crossing the Frisco railroad at Depew, Creek Nation. In the vicinity of Key West the straight winds are reported to have destroyed property to the value of $2,500 and injured six persons. The tornado here had a path a quarter of a mile wide. The storm reached Depew, fifteen miles northeast, about 5:30 p. m., and there destroyed thirty or forty houses and injured two men. Heavy rainfall accompanied this storm and caused great damage.

A second tornado, with a path two hundred yards wide, occurred almost simultaneously six or eight miles to the south, along a parallel path between Arlington and Newby. At the confluence of Pataqua Creek and Deep Fork of Canadian River this tornado killed four persons. Three others were injured and ten houses destroyed along its path. Heavy rain and hail fell after the tornado had passed.—*C. A., jr.*

[1] Reprinted from Science, 1909, **30**(n.s.):302-3.
[2] See Science, 1908, **27**(n.s.):315.

METEOROLOGICAL REGISTRATIONS IN SAMOA. 1902-1906. II. RAINFALL.[1]

By OTTO TETENS, Ph. D. Dated Berne, Switzerland, March 9, 1909.

INSTRUMENT.

The self-registering raingage was one designed by Professor Hellman and constructed by Fuess. The receiving area is 200 square centimeters. There are two chambers, the upper one of small diameter empties its contents by means of a syphon, as soon as 10 millimeters of rain water have been collected, into the lower and larger vessel. The larger vessel serves as a reservoir and the quantity collected therein is measured daily by means of a glass graduate. The upper chamber also contains a float to which is attached a pen registering the height of the water (from 0-10 millimeters) on a drum which revolves once in about 26 hours. Owing to the small diameter of the upper vessel, the scale of rainfall is highly magnified showing 0.1 millimeter. This instrument was erected at Apia in as favorable an exposure as was possible. The surrounding cocoanut palms, viewed from the raingage, did not exceed an altitude of 45 degrees. It is difficult to say whether the palms have in general affected the catch of the gage; occasional comparisons were made with raingages placed near by and the results were in satisfactory agreement.

[1] For I. Winds, see Monthly Weather Review, March, 1909, 37:93-5.

MONTHLY RAINFALL.

The separate months.

The following table, Table 1, gives for each month the duration, intensity, and quantity of rain, and summary of rainfalls.

Although the rainy season in Samoa is not so pronounced as in some other countries, yet it is very distinct. This is especially true of the northern coast of Upolu where the trade winds, during the dry season, come from a more southerly direction and the north coast thus becomes the lee shore. During the rainy season the winds blow from a more northerly direction and the north coast is then the weather shore. On the south coast the influence of the wind is just contrary to the above, and the two seasons are therefore more equal. In order to contrast the two seasons the months have been grouped under them so that now the tables begin with November, the first month of the wet season. The observations recorded embrace 4 wet and 4 dry seasons.

TABLE 1.—*Observed rainfall data for Apia, Samoa, 1902-06.*

Months.	Duration.														
	Number of rain days.					Number of rain hours.					Number of rain minutes (: 1,000).				
	1902-1903.	1903-1904.	1904-1905.	1905-1906.	1906.	1902-1903.	1903-1904.	1904-1905.	1905-1906.	1906.	1902-1903.	1903-1904.	1904-1905.	1905-1906.	1906.
Wet season.															
November	19	23	22	14	21	95	120	84	82	132	2.1	3.3	1.6	2.5	4.3
December	14	20	24	19	25	65	127	151	84	137	1.7	3.3	3.5	2.5	4.8
January	23	28	22	18	.....	165	202	140	79	.....	5.4	5.9	3.8	3.1	.....
February	21	27	15	18	.....	159	200	60	75	.....	5.2	6.3	1.8	2.1	.....
March	16	20	19	24	.....	99	120	89	128	.....	2.7	3.3	2.9	4.3	.....
April	20	27	19	23	.....	148	199	107	84	.....	4.8	5.9	3.9	1.0	.....
Dry season.															
May	15	19	7	16	.....	88	83	37	76	.....	2.0	1.8	0.6	2.3	.....
June	17	12	11	19	.....	112	56	80	92	.....	2.9	1.1	2.0	2.4	.....
July	13	13	10	17	.....	57	65	34	73	.....	1.2	1.7	0.7	1.8	.....
August	17	18	13	20	.....	85	122	69	115	.....	1.6	3.3	2.1	3.1	.....
September	17	21	10	14	.....	78	93	44	66	.....	1.7	2.8	1.5	1.9	.....
October	20	16	14	20	.....	136	65	41	61	.....	3.8	2.0	1.4	2.1	.....
Year.	212	244	186	222	.....	1,287	1,452	936	1.015	.....	35.1	40.9	25.9	29.0	.....
Dry season	113	145	121	116	.....	731	968	631	532	.....	22.1	28.1	17.5	15.4	.....
Wet season	99	99	65	106	.....	556	484	305	483	.....	13.0	12.8	8.4	13.5	.....
Character:															
Dry season	(+0.06)	+0.16	+0.18	+0.14	.....	(+0.12)	+0.27	+0.22	+0.14	.....	(+0.23)	+0.34	+0.23	+0.16	.....
Wet season	−0.11	−0.13	−0.26	(−0.04)	.....	−0.18	−0.21	−0.28	(−0.04)	.....	−0.28	−0.24	−0.29	(−0.06)	.....

Months.	Intensity. Centimeters per 1,000 rain minutes.					Quantity. Centimeters.					Rainfalls.									
											Total number of rainfalls.					Rainfalls of more than one hour's duration.				
	1902-1903.	1903-1904.	1904-1905.	1905-1906.	1906.	1902-1903.	1903-1904.	1904-1905.	1905-1906.	1906.	1902-1903.	1903-1904.	1904-1905.	1905-1906.	1906.	1902-1903.	1903-1904.	1904-1905.	1905-1906.	1906.
Wet season.																				
November	10	7	10	7	7	20	23	17	17	31	78	102	68	56	79	8	11	5	15	22
December	5	9	7	7	6	9	38	26	17	27	49	113	125	57	93	9	11	12	11	28
January	7	11	10	7	.....	38	68	38	14	.....	113	174	127	55	.....	23	21	10	14	.....
February	14	10	8	6	.....	71	64	14	14	.....	117	146	46	54	.....	20	27	10	13	.....
March	6	8	8	11	.....	16	27	22	48	.....	82	94	54	80	.....	8	26	16	29	.....
April	8	8	5	7	.....	37	60	21	14	.....	117	168	59	72	.....	24	23	16	8	.....
Dry season.																				
May	6	10	2	8	.....	12	18	1	13	.....	70	75	34	60	.....	7	2	2	13	.....
June	9	11	7	7	.....	26	12	15	16	.....	103	49	69	71	.....	17	3	7	8	.....
July	6	6	3	4	.....	7	11	6	8	.....	45	51	24	59	.....	7	11	4	7	.....
August	6	3	6	4	.....	10	10	13	12	.....	75	106	43	88	.....	5	14	10	15	.....
September	11	7	6	5	.....	18	21	10	9	.....	73	74	28	47	.....	5	12	6	9	.....
October	9	7	4	5	.....	33	15	5	10	.....	116	52	26	39	.....	19	5	8	9	.....
Year.	8.5	8.5	7.6	6.7	.....	297	347	186	193	.....	1,038	1,204	703	747	.....	152	166	106	151	.....
Wet season	8.6	9.3	7.8	7.9	.....	191	280	137	122	.....	556	797	479	383	.....	92	119	69	90	.....
Dry season	8.2	6.7	5.8	5.3	.....	106	86	40	71	.....	482	407	224	364	.....	60	47	37	61	.....
Character:																				
Wet season	(+0.03)	+0.10	+0.10	+0.16	.....	(+0.26)	+0.44	+0.32	+0.32	.....	(+0.06)	+0.26	+0.20	+0.13	.....	(+0.19)	+0.35	+0.22	+0.28	.....
Dry season	−0.04	−0.10	−0.13	(−0.18)	.....	−0.32	−0.34	−0.42	(−0.24)	.....	−0.14	−0.18	−0.28	(−0.02)	.....	−0.24	−0.28	−0.33	(−0.17)	.....

"Character" of seasons defined.—The total amounts for the year and the two seasons give some interesting facts. The *character* of the one season in comparison to that of the preceding and following one is here expressed by a figure which is obtained by taking the difference of logarithms for the season in question and for the geometric mean of the two contiguous seasons. This definition of "character" does not apply to the first and last seasons observed as these lack either a preceding or succeeding season; therefore the "character" of such a season has been derived by comparison with one season only and its weight is ½. In the tables the figures representing this character are in ( ).

Duration of rain.—The duration of rain has been expressed separately by the number of rain days, rain hours, and rain minutes, for which the mean "characters" are 0.15, 0.20 and 0.24, respectively, showing that through the rain minutes the seasons receive their most potent character.

Rain intensity.—The rain intensity does not characterize the seasons even as well as do the number of rain days, the resulting mean "character" by intensity being only 0.11. As the depth or quantity is equal to the product of duration and intensity, the "character" by quantity equals the sum of the "characters" by duration and intensity. For this reason the quantity of rain is the most important element in characterizing the seasons; the mean seasonal "character" by rain quantity is 0.35. The mean seasonal "character" by the number of rainfalls is 0.18, but by those of more than one hour's duration, 0.27. The different rain features for the two seasons as observed at Apia for eight seasons, when arranged according to their mean "characters" rank as follows:

	Mean seasonal "character."
1. Rain quantity	0.35
2. Rainfalls of more than one hour's duration	0.27
3. Duration by rain minutes	0.24
4. Duration by rain hours	0.20
5. Rainfalls	0.18
6. Duration by rain days	0.15
7. Intensity	0.11

A longer period of observation will undoubtedly change the above averages, as the data for the single years vary greatly. In this respect the values of the individual months show the greatest variations, but the seasonal and even the yearly totals are likewise remarkable. If we consider only the last-named, the ratio of the largest and smallest of the four totals is 1.3, 1.6, 1.6, for the rain days, rain hours, and rain minutes, and 1.3 and 1.9 for intensity and quantity, while the number of rainfalls shows the extreme ratio 1.7 and the rainfalls of more than one hour's duration, 1.6. Thus the four years of observation have sufficed to determine fairly well the average rain intensity and the annual number of rain days, whereas it will require a much longer series of observations to determine equally well the average quantity. However, it is well known that precipitation is everywhere an irregular element.

Average for four years.

The average monthly values of the precipitation features for the four years, 1902–06, are given in Table 2. The "seasonal ratio" is obtained by dividing the average for the wet season by the average for the dry season. The logarithm of the seasonal ratio is equivalent to the mean seasonal "character." The maximum and minimum values of the various factors here presented fall in various months, being found in all the months excepting November and December. It will be interesting to learn, if, after a longer series of observations is available, the same characteristics for each month which appear in the 24 columns of Table 2 will be essentially changed. In this respect Table 1 of this chapter throws some light upon this speculation as the data for each month are given. Some months show decided variations, and it may be safely expected that these fluctuations will recur in later years. In order to show these fluctuations more clearly the quantity and duration "characters" for each month have been calculated and these are given in Table 3.

As the division of the year into 12 months is an accidental one from a meterological point of view while the rainfall is the basis of the seasonal division, the meteorological "character" for the single month cannot be expected to be as steady as is the seasonal character. The unsteady character of the single months appears in Table 3.

TABLE 2.—*Average rainfall data, November, 1902, to October, 1906, at Apia, Samoa.*

Months.	Duration.						Intensity.				Quantity.		Percentages.			Distribution.			Rainfalls.					
	Monthly number of			Daily number of		Hourly number of rain min.	Centimeters per										Rain minutes.		Number of rainfalls.		Average rainfall.		Rainfalls of more than 1 hour's duration. Number.	
	Rain days.	Rain hours.	Rain min. (1,000).	Rain hours.	Rain minutes.		Rain day.	24 rain hours.	24×60 rain minutes.	1,000 rain minutes.	Monthly.	Daily.	Rain days per 100 days.	Rain hours per 100 hours.	Rain minutes per 100 minutes.	Rain hours per rain day.	Per rain day.	Per rain hour.	Monthly.	Daily.	Quantity.	Duration.	Per month.	Per 100 rainfalls.
Wet season.							cm.	cm.	cm.	cm.	cm.	cm.									cm.	min.		
November	20	95	2.4	3.2	79	3.3	1.0	4.8	12	8.0	19	0.64	65	13	5.5	4.9	122	25	76	2.5	0.29	31	10	13
December	19	107	2.8	3.4	89	3.8	1.0	4.5	10	7.2	20	0.64	64	14	6.2	5.5	144	26	86	2.8	0.23	32	11	13
January	23	146	4.3	4.7	139	5.8	1.8	6.4	13	9.1	39	1.27	73	20	9.7	6.4	190	30	117	3.8	0.33	37	17	14
February	20	124	3.8	4.4	136	5.7	2.0	7.8	15	10.1	40	1.38	72	18	9.5	6.1	190	31	91	3.2	0.45	42	18	19
March	20	109	3.3	3.5	107	4.5	1.4	6.2	12	8.6	28	0.92	64	15	7.4	5.5	167	30	80	2.6	0.36	41	20	25
April	22	134	4.1	4.5	138	5.8	1.4	5.4	11	7.3	30	1.01	74	19	9.6	6.0	186	31	104	3.5	0.29	40	18	17
Dry season.																								
May	14	71	1.7	2.3	54	2.2	0.9	4.1	10	7.2	12	0.39	46	10	3.8	5.0	118	24	60	1.9	0.20	28	6	10
June	15	85	2.1	2.8	70	2.9	1.1	4.8	12	8.0	17	0.56	49	12	4.9	5.7	143	25	73	2.4	0.23	29	9	12
July	13	58	1.3	1.9	43	1.8	0.6	3.3	8	5.8	8	0.25	43	8	3.0	4.4	101	23	45	1.4	0.18	30	7	16
August	17	98	2.5	3.2	81	3.4	0.7	2.7	6	4.4	11	0.36	55	13	5.7	5.8	149	26	78	2.5	0.14	32	11	14
September	16	70	2.0	2.3	65	2.7	0.9	4.9	11	7.4	14	0.48	57	10	4.5	4.6	127	28	56	1.8	0.26	35	8	14
October	18	76	2.3	2.5	75	3.1	0.9	4.9	10	6.7	16	0.50	56	10	5.2	4.3	134	31	58	1.9	0.27	40	10	18
Year.	18	98	2.7	3.2	90	3.7	1.2	5.2	11	7.8	21	0.70	59	13	6.2	5.4	152	28	77	2.5	0.28	35	12	16
Dry season	21	119	3.5	3.9	115	4.8	1.4	6.0	12	8.5	30	1.00	68	16	8.0	5.8	168	29	92	3.1	0.32	38	15	17
Wet season	15	76	2.0	2.5	65	2.7	0.8	4.1	9	6.5	13	0.42	50	10	4.5	4.9	130	26	62	2.0	0.21	32	9	14
Seasonal ratio *	1.3	1.6	1.7	1.6	1.8	1.8	1.7	1.4	1.3	1.3	2.3	2.4	1.4	1.6	1.8	1.2	1.3	1.1	1.5	1.5	1.5	1.2	1.8	1.2

* = mean Wet ÷ mean Dry.

TABLE 3.—*Variations in quantity and duration of rainfall at Apia, Samoa, expressed by the respective "characters."*

Month.	Quantity. 1902–1903.	Quantity. 1903–1904.	Quantity. 1904–1905.	Quantity. 1905–1906.	Quantity. 1906.	Quantity. Average.	Quantity. Mean departure from average.	Duration. 1902–1903.	Duration. 1903–1904.	Duration. 1904–1905.	Duration. 1905–1906.	Duration. 1906.	Duration. Average.	Duration. Mean departure from average.
Wet season.														
November	(+0.34)	−0.12	−0.07	+0.24	+0.27	+0.11	0.18	(+0.08)	−0.02	−0.22	+0.11	+0.13	+0.01	0.11
December	−0.48	−0.15	+0.01	+0.04	(−0.05)	−0.13	0.16	−0.28	−0.13	+0.15	+0.05	(+0.05)	−0.04	0.15
January	+0.20	+0.20	+0.30	−0.03	....	+0.17	0.10	+0.25	+0.11	+0.19	−0.04	....	+0.13	0.09
February	+0.41	+0.17	−0.33	−0.28	....	−0.01	0.30	+0.13	+0.16	−0.28	−0.15	....	−0.04	0.18
March	−0.48	−0.31	+0.13	+0.54	....	−0.03	0.36	−0.27	−0.27	+0.04	+0.34	....	−0.04	0.23
April	+0.42	+0.36	+0.64	−0.33	....	+0.27	0.30	+0.32	+0.38	+0.46	−0.22	....	+0.24	0.22
Dry season.														
May	−0.40	−0.14	−1.25	+0.08	....	−0.43	0.41	−0.28	−0.14	−0.63	+0.04	....	−0.25	0.20
June	+0.43	−0.06	+0.79	+0.13	....	+0.32	0.29	+0.29	−0.20	+0.46	+0.07	....	+0.16	0.22
July	−0.32	−0.01	−0.38	−0.25	....	−0.24	0.12	−0.27	−0.05	−0.44	−0.19	....	−0.24	0.12
August	−0.09	−0.16	+0.24	+0.15	....	+0.04	0.16	+0.05	+0.18	+0.29	+0.24	....	+0.19	0.08
September	+0.02	+0.22	+0.06	−0.08	....	+0.06	0.08	−0.16	+0.03	−0.06	−0.13	....	−0.08	0.06
October	+0.20	−0.09	−0.37	−0.23	....	−0.12	0.18	+0.20	−0.02	−0.12	−0.13	....	−0.02	0.11

From the column "Mean Departures" of Table 3 it can be seen that the five months, February to June, are the most inconsistent ones both in quantity and duration of rainfall.

DAILY RAINFALL.

TABLE 4.—*Daily rainfall period at Apia, Samoa. Mean hourly values,* 1903–1906.

	Quantity. Thousandths of a centimeter. Year.	Quantity. Wet season.	Quantity. Dry season.	Duration. rain minutes. Year.	Duration. Wet season.	Duration. Dry season.	Intensity. Thousandths of a centimeter per rain minute. Year.	Intensity. Wet season.	Intensity. Dry season.
0-1 a. m.	33	43	22	3.9	4.6	3.2	8.0	9.2	6.9
1-2 a. m.	26	30	22	3.8	4.4	3.1	7.0	6.9	7.1
2-3 a. m.	32	52	12	4.0	4.8	3.1	7.4	10.8	3.9
3-4 a. m.	34	60	9	4.1	5.7	2.6	7.0	10.6	3.4
4-5 a. m.	30	49	11	4.1	5.6	2.7	6.5	8.9	4.1
5-6 a. m.	29	45	13	4.3	5.8	2.8	6.2	7.7	4.7
6-7 a. m.	28	48	10	3.8	5.1	2.4	6.6	9.3	3.9
7-8 a. m.	27	40	15	3.7	5.0	2.4	7.2	8.0	6.3
8-9 a. m.	26	36	16	3.7	4.7	2.6	6.8	7.7	5.9
9-10 a. m.	26	32	20	3.6	4.5	2.8	7.2	7.1	7.3
10-11 a. m.	22	28	16	3.4	4.5	2.3	6.5	6.2	6.8
11-12 a. m.	26	32	21	3.4	4.2	2.6	7.8	7.6	8.0
Noon.									
0-1 p. m.	27	42	12	3.6	4.4	2.2	7.5	9.4	5.6
1-2 p. m.	26	36	17	3.8	5.0	2.7	6.7	7.1	6.3
2-3 p. m.	40	54	26	4.3	5.5	3.1	9.2	9.8	8.5
3-4 p. m.	32	36	28	4.4	5.4	3.3	7.6	6.6	8.7
4-5 p. m.	37	54	20	4.8	5.9	3.3	7.6	9.2	6.1
5-6 p. m.	38	50	27	4.1	5.6	2.7	9.4	8.9	10.0
6-7 p. m.	31	42	20	4.2	5.4	3.0	7.4	7.9	6.8
7-8 p. m.	27	36	18	3.6	4.9	2.4	7.6	7.3	7.7
8-9 p. m.	28	39	17	3.3	4.6	2.0	8.6	8.4	8.8
9-10 p. m.	31	38	23	3.3	4.3	2.4	9.4	8.9	9.8
10-11 p. m.	28	42	14	3.5	4.7	2.4	7.5	9.0	6.0
11-12 p. m.	28	43	14	3.7	4.5	2.8	7.0	9.2	4.9

In order to diminish the accidental fluctuations it seemed advisable to adjust the data of Table 4 by using the formula $b'=\frac{1}{4}(a+2b+c)$, where a, b, c, are the originally recorded falls of three successive hourly intervals, and b' is the resulting adjusted value for the second hour. After computing these the values for quantity and duration have been converted into per cents of the daily totals, and thus the curves of fig. 1 have been constructed.

It appears from fig. 1 that the duration presents the least daily fluctuations, they amounting to a little more than 1 per cent. The durations for the two seasons agree very well, both showing the typical maximum between 3 and 6 p. m. This is also the time of maximum quantity. Evidently this maximum is caused by the daily temperature maximum which generally throws the atmosphere into very unstable equilibrium. This statement applies to Apia during the dry season only. In the wet season the northerly winds coming from the high seas favor precipitation. The atmospheric radiation during the night cools the upper strata whereas the lower strata are kept warm by the sea water. Thus a nocturnal unstable equilibrium is to be expected, especially during the rainy season, and owing to this fact the nocturnal rain maximum from 3 to 5 a. m. of the wet season, as shown by the three diagrams, is not surprising. Analyzing the results we obtain the following formulas expressing the departures from the mean average:

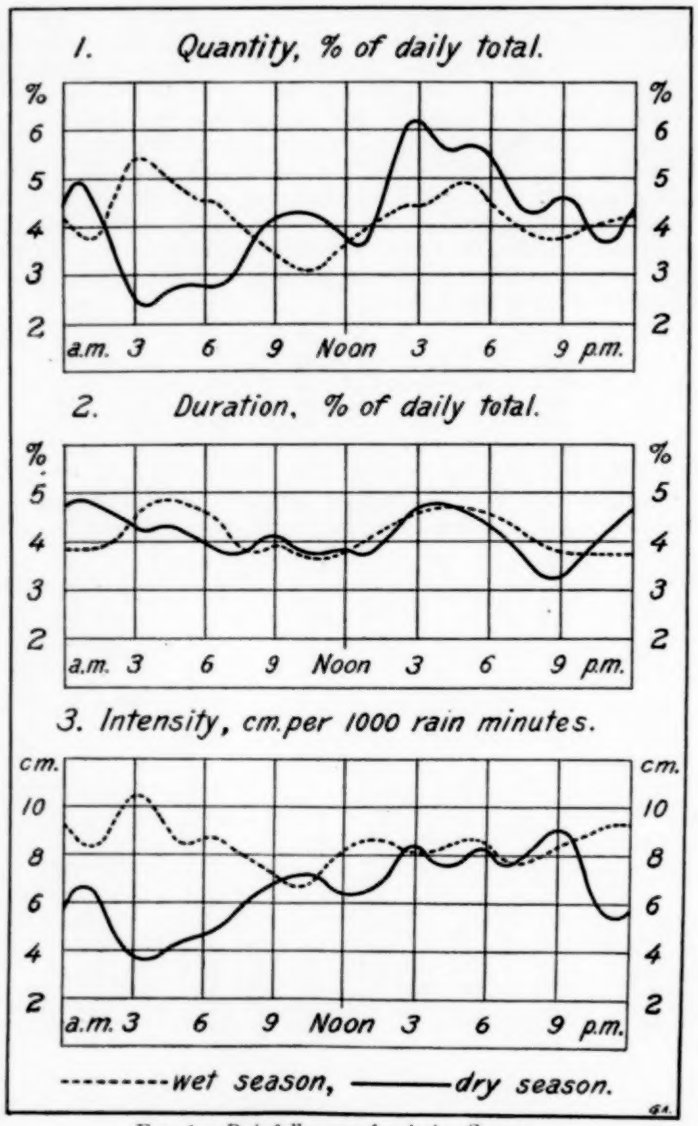

FIG. 1.—*Rainfall curves for Apia, Samoa.*

1. *Quantity:*
   Wet season, $=0.3 \sin(85°+h)+0.7 \sin(324°+2h)$ (1)
   Dry season, $=1.2 \sin(195°+h)+0.2 \sin(395°+2h)$ (2)
2. *Duration:*
   Wet season, $=0.1 \sin(222°+h)+0.5 \sin(310°+2h)$ (3)
   Dry season, $=0.1 \sin(116°+h)+0.4 \sin(358°+2h)$ (4)
3. *Intensity:*
   Wet season, $=0.7 \sin(82°-h)+0.6 \sin(358°+2h)$ (5)
   Dry season, $=1.8 \sin(195°-h)+0.7 \sin(166°+2h)$ (6)

These analytic formulas verify the previous statements. In Quantity and Intensity the first term's angular values agree very well, placing the daily maximum according to the thermal influence. The second term's angular values are equal in Quantity and Duration causing two maxima from 3^h-4^h, two minima from 9^h-10^h. These double daily periods of rain may be explained by the fluctuations in atmospheric pressure. The two phenomena are exactly opposite in phase. According to formulas 1 and 2 the variation of Quantity is about 0.07 millimeters during the wet season and 0.01 during the dry season.

It must now be seen if these amounts may be explained by the daily tropical fluctuations of the barometer. We have the equations:

$$dQ=c_v.\,dt+Apdv,$$
$$pv=RT,$$
$$AR=c_p-c_v, \text{ where}$$

dQ=the quantity of heat given to a certain quantity of air,
c_p=the specific weight (=0.238) of air at a constant pressure, p.
c_v=the specific weight of air at a constant volume, v.
A=the reciprocal thermal equivalent (1/427).
p=pressure (=760 mm.)
v=volume.
R=constant of the gas (=29.3).
t=centigrade temperature of the gas.
T=absolute temperature (=300°A).

From the above equations we easily derive the following ones:

$$pdv+vdp=Rdt,$$
$$dQ=c_vdt+ARTdt-Avdp,$$
$$dQ=c_vdt-ART.\frac{dp}{p}.$$

The adiabatic condition gives $dQ=0$, from which we derive

$$dt=\frac{ARTdp}{c_pp}.$$

By substituting the above given values of the different quantities in this equation the result is

$$dt=0.114\,dp,$$

therefore the mean daily fluctuations of the air pressure amounting to more than 1 millimeter cause temperature fluctuations of more than 0.1°C. Saturated air at about 25°C. condenses more than 0.1 gram water per cubic meter for a decrease of 0.1°C. in temperature, or more than 100 grams per 1,000 cubic meters. This quantity is equivalent to a precipitation of 0.1 millimeter over an area of 1 square meter. Although the air is not always near the point of saturation, yet the quantity ascribable to the daily barometric fluctuations is sufficient to explain the above-mentioned daily amplitude of 0.07 millimeter.

Since the rainfall is usually observed but twice a day in the Tropics, 6 a. m. and 6 p. m., it is of interest to figure the daily and nightly percentage. The result is as follows:

Percentage of day and night precipitation, Apia, Samoa.

Period.	Night.	Day.
	%	%
Year	50.0	50.0
Wet season	51.5	48.5
Dry season	46.4	53.6

GRADES OF RAIN.

In reference to the rain quantity fallen during certain intervals of time, for example hours or days, a new gradation of rain has been introduced. As the soil, plants, tanks, etc., are unable to absorb more than a certain quantity of rain, the excess is obliged to overflow and thereby become useless. From a practical point of view the usual "additive" scale seems to overestimate the amount of rain falling at one time; and so in order to find a more adequate gradation a logarithmic scale seemed the most satisfactory. The rain being subject to the physical sensibilities of mankind Weber's law[2] becomes applicable which also requires a logarithmic gradation.

Considering 0.1 millimeter as unity and $10^{\frac{1}{2}}$ as the ratio of quantities corresponding to two succeeding grades, the values for whole grades are ....10^0, $10^{\frac{1}{2}}$, 10^1, $10^{\frac{3}{2}}$, 10^2, etc.
which equal............... 1, 3.16, 10, 31.6, 100, etc.
The limits of two succeeding grades are.. $10^{\frac{1}{4}}$, $10^{\frac{3}{4}}$, $10^{\frac{5}{4}}$, etc.
which equal..........................1.78, 5.63, 17.78, etc.

When it is desired to convert these quantities into inches, considering 0.01 inch as unity, the above figures are multiplied by 0.3937.

Hence Table 6 is derived.

TABLE 6.—*Table of rain "grades" and their equivalents.*

Grade of rain.	Quantity measured.	
	Unity=0.1 mm.	Unity=0.01 inch.
0	½ and less	¼ and less
1	1	½
2	from 2 to 5	1 and 2
3	from 6 to 17	from 3 to 7
4	from 18 to 56	from 8 to 22
5	from 57 to 177	from 23 to 70
6	from 178 to 562	from 71 to 221
7	from 563 to 1778	from 222 to 700
8	from 1779 to 5623	from 701 to 2213

In Samoa the rain falls in large quantities, and therefore it might be permissible in the original work to class falls of 0.1 millimeter and less in the 0-grade of rain; but in order that this method of classifying rainfalls may find application in discussions of dryer climates this Summary has classed precipitations of 0.05 millimeter and less in grade 0, and 0.1 millimeter in grade 1.

Hourly rain "grades."

This method of expressing rainfalls by "grades" makes it possible to publish on one page the hourly records of a self-registering rain-gage for 12 months. As an example the wet and dry seasons of November, 1902 to October, 1903, are given in Table 7.

From these 12 months of single hourly rain "grades" tables 8, 9, 10, and 11 are derived. Table 8 shows for each month the number of hours characterized by each "grade." It appears that "grades" 3–6 are the most frequent during the wet season, whereas the average "grade" for the rain hours is not very different for the two seasons.

[2] Weber's Law, Fechner's Law, or the Psycho-physical Law, may be formulated thus—"The difference between any two stimuli is experienced as of equal magnitude, in case the mathematical relation of these stimuli remains unaltered Or, otherwise expressed: In order that the intensity of a sensation may increase in mathematical progression, the stimulus must increase in geometrical progression. It is also expressed by Fechner in the form: The sensation increases as the logarithm of the stimulus." For example, "If we can distinguish 16 oz. and 17 oz., we shall we able to distinguish 32 oz. and 34 oz., but not 32 oz. and 33 oz., the addition being in each case, for example, 1/16 of the preceding stimulus."—*Enclyclopedia Britannica*, 1888–91. *Ninth edition. Vol.* 24, *p.* 469. *Art.* "*Weber's Law.*"

Table 7.—*Hourly "grades" of rain at Apia, Samoa, 1902–1903.*

WET SEASON.

1902.	a.m.	6 a.m.	M. p.m.	6 p.m.
Nov. 1	......	......	......	......
	......	......	......	.3..21
	..20..	2..452	2....2	......
	..3.4.	....3.	20....	......
	......	......	......	...3..
6	43301.	..4...	......	......
	..2...	......	......	......
	......	......	......	......
	......	....3.	..1...	......
	......	......	......	13
11	......	......	2	......
	...53.	......	......	......
	......	......	......	2
	.1.20.	3	5331..	......
	......	......	......	......
16	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
21	......	..35..	.15...	4
	...244	4251.5	1.41..	.3243.
	3.533.	32....	......	.4...2
	......	..3321	.13443	523...
	3	1..4..	50..40	......
26	......	......	......	......
	......	......	2....5	43.1..
	30	1.....	......	......
	......	......	......	......
	......	......	......	......
Dec. 1	...0..	......	......	......
	.13...	3.....	...423	....1.
	....1.	......	......	......
	......	......	......	......
	......	......	......	......
6	..32..	......	......	....3.
	..2.2.	......	33.41.	......
	...01.	......	......	......
	......	......	......	......
	......	......	......	......
11	......	......	......	......
	......	......	..1...	......
	......	......	......	......
	......	......	......	......
	12	.20221	222121	..4543
16	032354	......	1	......
	......	......	......	.30...
	......	......	......	......
	......	......	......	......
	......	......	......	......
21	......	......	......	......
	......	......	......	.00413
	1	3.....	...3..	......
	......	......	......	......
	......	......	......	......
26	......	......	54	42....
	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	.44421	0.....	......
31	......	......	......	......
1903. Jan. 1	2	533355	544424	2.22..
	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	.42444	232...	......
6	......	...321	.3442.	......
	......	22	10....	..0...
	...432	.4....	......	......
	......	..2...	3	..2455
	645432	..110.	......	......
11	53	.45424	43..31	.0....
	....3.	342...	332444	545641
	146632	332100	10....	......
	......	3	2.....	......
	......	22	......	......
16	401134	44431.	5	31....
	1..12.	..401.	......	......
	......	......	...23.	......
	......	......	......	......
	......	......	......	42
21	...20.	......	......	......
	.03121	.22321	1..0..	......
	......	...01.	......	20
	431.1.	.23301	0.....	..332.
	......	......	......	......
26	......	......	......	..503.
	30343.	......	......	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
31	......	......	......	...32.

1903.	a.m.	6 a.m.	M. p.m.	6 p.m.
Feb. 1	34....	......	......	......
	......	...40.	......	31
	......	......	......	......
	......	......	....1.	......
	...233	3110..	......	......
6	1...1.	......	.32...	......
	......	......	.0....	..41.3
	0...21	.144..	..51..	...2..
	12.0..	44	253655	432...
	......	..1223	454566	654445
11	556666	554042	143442	0.22.0
	13513.	...225	655544	41.365
	551455	334.21	.35445	0343.2
	3242.1	.3....	.5431.	..4321
	1.....	......	......	......
16	3	......	......	......
	......	......	......	......
	3.....	......	......	......
	......	......	......	3
	......	......	......	......
21	......	......	......	......
	...4..	45	1	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
26	2.....	4432.2	....0.	......
	4.....	......	.4023.	......
	......	......	...22.	......
Mar. 1	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	......	.1....	......
	......	......	......	......
6	......	52	434554	3.....
	.1....	......	......	......
	......	...3..	.32332	12241.
	52313.	2.14..	13....	442432
	123243	31....	..4...	......
11	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
	...213	...2..	......	......
16	......	......	3	.20...
	.11423	4.121.	..32.0	2122..
	33	31....	......	......
	......	44	3..2..	......
	......	......	......	......
21	......	......	......	......
	......	......	......	.24..1
	......	......	4.....	.3342.
	41	......	05	440335
	2..2..	......	......	......
26	......	......	......	......
	......	......	......	.0....
	......	......	......	......
	......	......	......	......
	......	......	......	......
31	......	......	......	......
April 1	......	......	......	......
	......	......	......	135..4
	40..23	343442	1...1.	......
	......	......	......	......
	......	......	......	321...
6	......	......	......	.451..
	...544	0.....	......	......
	......	......	......	2
	1.....	313...	......	..44.5
	551...	...0..	..60..	.1....
11	......	......	......	......
	......	......	......	......
	......	......	......	3.....
	......	......	......	......
	......	......	......	......
16	......	......	......	......
	......	.2521.	......	36
	321..2	......	...255	23....
	...253	.33321	2	..2.2.
	...11.	..3424	4153..	.22...
21	.33433	31....	......	30..35
	332...	212..0	1.....	...253
	34	..1...	..3444	5542.1
	....2.	......	..3210	.53224
	4444.2	333345	544455	2.111.
26	......	......	......	......
	......	......	30	......
	......	......	......	2.....
	......	......	......	......
30	......	......	......	....

DRY SEASON.

1903.	a.m.	6 a.m.	M. p.m.	6 p.m.
May 1	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	......	....1.	......
6	13....	......	......	3.....
	......	......	......	......
	......	.1....	..52..	...11.
	......	......	.11...	......
	......	......	......	......
11	......	......	......	......
	......	......	......	......
	......	3	2.....	213402
	341...	03	0....2	2210.4
	1...1.	...2..	3	1....4
16	44...4	131...	1..2..	......
	...04.	2.4...	...4..	2....2
	..20..	......	......	1.....
	......	.14100	21..24	54442.
	1.....	......	......	......
21	...020	......	......	......
	......	......	......	......
	......	......	...33.	.45444
	432.23	121...	......	......
	......	......	......	......
26	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
31	......	......	......	......
June 1	......	......	......	......
	......	......	......	......
	......	..2...	......	231...
	....1.	34	221...	...454
	32....	......	......	......
6	......	......	......	......
	......	......	......	......
	......	......	......	352...
	...1..	1	12..2.	32....
	...122	2.....	......	......
11	......	......	......	......
	......	......	...52.	1.....
	......	......	......	......
	......	......	......	......
	.621.2	1....0	.1.34.	......
16	...22.	1	......	......
	.20...	...22.	2..451	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
21	......	......	......	......
	......	..341.	.1.2..	......
	......	......	......	......
	......	......	......	...101
	3.....	......	.203.5	223432
26	46533.	444332	445645	334553
	344.3.	......	......	24....
	......	......	......	......
	......	......	..10..	......
	11	01.22.	53	43....
July 1	......	...411	......	2
	......	......	.3....	......
	......	......	..33..	......
	......	......	......	2...12
	.22...	4.....	36	2.332.
6	...1..	.24432	34..02	1.....
	......	......	..1...	......
	.51.22	10233.	.0....	......
	......	......	......	......
	......	......	......	......
11	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
16	......	......	......	......
	......	......	......	.120..
	....0.	......	......	......
	02.423	2.....	...22.	.0....
	......	......	......	......
21	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
26	......	......	......	......
	......	......	......	......
	......	.2....	......	......
	......	......	......	......
	.1....	4.....	......	......
31	......	......	......	......

1903.	a.m.	6 a.m.	M. p.m.	6 p.m.
Aug. 1	......	......	......	......
	......	......	......	......
	......	022021	0.....	......
	......	......	......	......
	..2221	1.....	......	......
6	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	......	....0.	42.431
	34444.	.1.3..	......	......
11	.0...1	333353	.0.122	....0.
	12....	.110..	......	4
	......	......	......	.2..31
	..1211	......	......	......
	.45445	350..2	2.....	......
16	......	......	....3.	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
21	......	......	......	......
	......	......	.3....	......
	.2...1	..1...	......	......
	......	......	......	......
	......	......	......	......
26	......	1..3..	......	2
	2....1	......	......	......
	......	......	......	......
	2.....	......	3	......
	......	1.2100	3.....	.1232.
31	04....	......	......	......
Sept. 1	......	......	......	......
	......	......	2.4154	4....2
	51...1	......	......	......
	......	......	......	......
	......	......	......	......
6	......	......	......	.2....
	......	......	......	......
	......	......	......	......
	......	......	...1..	......
	......	......	......	...0.2
11	......	...311	05	320135
	.1..11	......	0343..	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
16	...344	3.....	......	32
	2.....	......	......	......
	......	......	......	......
	......	4	10....	......
	......	32....	......	......
21	......	......	......	......
	......	......	....2.	......
	......	......	......	......
	......	......	......	......
	......	......	......	......
26	......	...0..	......	......
	......	......	......	.3....
	3.1..4	53.634	334554	5652..
	..0.1.	......	1	21...0
	201...	...3.3	0.....	2.....
Oct. 1	......	......	......	......
	......	......	......	......
	......	...1..	.0...2	......
	......	......	......	......
	..2...	32132.	.42.1.	202...
6	1.1441	......	......	......
	......	......	1	.23244
	441...	......	......	......
	......	......	....1.	......
	......	......	......	......
11	0	...24.	..313.	.34663
	344323	3421..	..5554	220...
	1.....	......	......	.22.44
	130444	.43556	422312	34321.
	...03.	......	..30.2	1
16	5531..	.321..	...51.	4....2
	......	......	......	......
	...221	......	......	......
	......	......	......	......
	......	......	......	......
21	......	......	......	......
	......	......	2	430..3
	1.....	.44...	......	......
	.1..4.	......	...13.	10....
	......	...0.3	......	.1..3.
26	53431.	6	52....	...21.
	......	......	......	......
	......	......	......	......
	......	......	......	......
	......	...3..	......	......
31	..11..	......	......	......

TABLE 8.—*The number of hours each rain "grade" occurred at Apia, Samoa, November, 1902, to October, 1903.*

Season.	Number of hours with grade								Number of hours with rain.	Average grade of the rain hours.
	No rain.	0	1	2	3	4	5	6		
Wet season.										
November	625	7	15	19	27	16	11	0	95	2.7
December	679	8	14	15	14	11	3	0	65	2.2
January	579	18	23	36	36	35	13	4	165	2.6
February	513	11	23	26	28	35	26	10	159	3.1
March	645	5	18	25	25	20	6	0	99	2.6
April	572	8	24	30	36	28	20	2	148	2.8
Dry season.										
May	656	10	23	20	12	20	3	0	88	2.2
June	608	6	21	30	22	19	11	3	112	2.6
July	687	7	10	20	11	7	1	1	57	2.1
August	659	12	21	21	16	11	4	0	85	2.1
September	642	10	16	13	17	11	9	2	78	2.5
October	608	10	29	28	28	27	10	4	136	2.6
Year.	7473	112	237	283	272	240	117	26	1287	2.6
Wet season	3613	57	117	151	166	145	79	16	731	2.7
Dry season	3860	55	120	132	106	95	38	10	556	2.4
Seasonal ratio	0.94	1.04	0.97	1.14	1.57	1.53	2.08	1.60	1.31	1.4

Table 9 gives a summary of the time characterized by hourly rain "grades." Two or more rainfalls, in the usual meaning of that term and of the previous statistics based on rain minutes, are now represented by one "grade" number unless their interval covers the full hour and then a period appears in Table 7 of hourly "grades."

TABLE 9.—*Frequency and intensity of rainfalls of various durations in "grade" hours. Apia, Samoa, 1902–1903.*

Rainfalls (=Successive hours with rain).

Number of successive hours showing "grades."	Number of rainfalls lasting			Sum of hours occupied by falls lasting			Intensity, average hourly "grade."			Sum of hourly "grades" for falls lasting		
	h 1–3	h 4–12	h >12	h 1–3	h 4–12	h >12	h 1–3	h 4–12	h >12	h 1–3	h 4–12	h >12
Wet season.				hrs.	hrs.	hrs.						
November	38	7	0	58	37	0	2.5	2.9	......	146	107	0
December	19	5	0	29	36	0	2.0	2.4	......	57	88	0
January	26	12	2	52	75	40	2.1	2.7	3.2	111	200	128
February	30	11	1	44	78	35	2.1	3.2	3.9	93	251	138
March	21	8	1	33	52	14	2.2	2.7	2.7	73	142	38
April	30	13	1	57	77	14	2.2	3.1	3.7	124	240	52
Dry season.												
May	27	7	0	43	45	0	2.0	2.4	......	85	109	0
June	29	7	1	53	38	21	2.1	2.7	3.9	112	102	82
July	23	3	0	39	18	0	1.9	2.6	......	76	46	0
August	27	8	0	37	48	0	1.7	2.3	......	63	112	0
September	25	5	1	40	25	13	1.9	2.6	4.2	75	64	55
October	41	7	2	64	41	31	2.0	3.0	3.3	128	122	101
Year.	336	93	9	549	570	168	2.1	2.8	3.5	1143	1583	594
Wet season	164	56	5	273	355	103	2.2	2.9	3.5	604	1028	356
Dry season	172	37	4	276	215	65	2.0	2.6	3.7	539	555	238
Seasonal ratio	0.95	1.51	1.25	0.99	1.65	1.58	1.10	1.12	0.95	1.12	1.85	1.50

A comparison shows that the number of rainfalls as computed by the "grade" hours, amount to about 4/10 of the number obtained in the usual way, by counting by minutes. In all four columns of Table 9 the rainfalls are divided into three groups, viz, those lasting from 1–3, from 4–12, and more than 12 successive "grade" hours. The group 4–12h. gives the highest seasonal ratio in each of the four columns.

Table 10 gives the daily arithmetical totals of the hourly "grades" as given in Table 7, and this is summarized in Table 11 which shows the number of days characterized by various groups of daily "grade" totals. The group embracing totals from 30 to 59 in Table 11 gives the largest seasonal ratio. The monthly averages and totals given in the last three columns of that table also bring out distinctly the difference between the two seasons.

TABLE 11.—*Number of days having various total hourly rain "grades." Apia, Samoa, 1902–1903.*

Daily totals of hourly "grades."	Number of days with						Average daily total for all days.	Monthly total.	Average daily total for the rain days.
	No rain.	0 to 9	10 to 29	30 to 59	60 to 99	>99			
Wet season.									
November	11	9	8	2	0	0	8	253	13
December	17	8	5	1	0	0	5	145	10
January	8	10	8	5	0	0	14	432	19
February	7	10	5	2	4	0	17	489	23
March	15	7	6	3	0	0	8	253	16
April	10	5	10	4	1	0	14	416	21
Dry season.									
May	16	6	8	1	0	0	6	194	13
June	13	7	9	0	1	0	10	296	17
July	18	9	4	0	0	0	4	122	9
August	14	12	4	1	0	0	6	175	10
September	13	11	5	0	1	0	6	194	11
October	11	9	6	4	1	0	11	351	18
Year.	153	103	78	23	8	0	9	277	16
Wet season	68	49	42	17	5	0	11	331	18
Dry season	85	54	36	6	3	0	7	222	13
Seasonal ratio.	0.8	0.9	1.2	2.8	1.7	....	1.6	1.5	1.4

Daily rain "grades."

According to a long established custom eye observations of rainfall are usually made but once during 24 hours, it therefore seems advisable and of general interest to compare the daily quantities of rain with those of the hourly grades referred to in this summary. Table 12 gives the daily "grades" for the first two seasons observed.

From Table 12 the statistics presented in Table 13 have been derived, showing that the two seasons are best characterized by the daily grade 6, grade 7 and 8 happen too seldom and the grades below 6 in the wet season do not predominate over the same in the dry season. The monthly totals of the daily grades give the seasonal ratio 1.3 which is only one-half of that given by grade 6, but still it is sufficient to characterize the two seasons in regard to the benefits derived from the rainfall.

TABLE 10.—*Daily arithmetical totals of hourly rain "grades" at Apia, Samoa, 1902–1903.*

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Wet season.																															
November	.	6	19	12	3	15	2	.	4	4	2	8	2	18	.	.	.	.	.	.	18	45	25	34	17	.	15	4	.	.	—
December	0	17	1	.	.	8	15	1	.	.	.	1	.	.	36	18	3	.	.	.	.	8	7	.	.	15	.	.	.	15	.
January	55	.	.	.	25	19	5	13	21	26	38	57	32	5	4	38	8	5	.	6	2	18	3	26	.	8	13	.	.	.	5
February	7	8	.	1	13	7	8	20	46	66	76	70	71	38	1	3	.	3	3	.	.	14	.	.	.	17	13	4	—	—	—
March	.	.	.	1	.	35	1	26	44	23	.	.	.	.	8	5	31	10	13	.	.	7	16	29	4	.	0	.	.	.	.
April	.	13	31	.	6	10	13	2	21	18	.	.	3	.	.	.	19	25	28	32	31	24	40	24	71	.	3	2	.	.	—
Dry season.																															
May	.	.	.	.	1	7	.	10	2	.	.	.	17	22	12	20	18	3	34	1	2	.	27	18	.	.	.	.	.	.	.
June	.	.	8	26	5	.	.	10	12	7	.	8	.	.	20	5	18	.	.	.	.	11	.	2	29	92	20	.	1	22	—
July	8	3	6	5	27	26	1	19	.	.	.	.	.	.	.	.	3	0	17	.	.	.	.	.	.	.	.	2	.	5	.
August	.	.	7	.	8	.	.	.	14	23	26	9	6	5	34	3	.	.	.	.	.	3	4	.	.	6	3	.	5	15	4
September	.	22	7	.	.	2	.	1	.	2	24	13	.	.	.	19	2	.	5	5	.	2	.	.	.	0	3	71	5	11	—
October	.	.	3	.	24	11	16	9	1	.	35	52	13	66	9	32	.	.	5	.	.	12	9	10	7	32	.	.	.	3	2

TABLE 12.—*Daily rain "grades," Apia, Samoa, 1902–1903.*

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Wet season.																															
November	.	3	5	4	3	5	2	.	3	3	2	5	2	5	.	.	.	.	.	.	6	6	6	6	6	.	6	3	.	.	—
December	0	5	1	.	.	4	4	1	.	.	.	1	.	.	6	6	3	.	.	.	.	4	4	.	.	6	.	.	.	5	.
January	7	.	.	.	5	5	3	5	6	6	6	7	7	3	3	6	4	3	.	4	2	4	2	5	.	5	4	.	.	.	3
February	4	4	.	1	4	3	5	5	7	7	8	7	7	6	1	3	.	3	3	.	.	5	.	.	.	5	5	3	—	—	—
March	.	.	.	1	.	6	1	5	6	5	.	.	.	.	3	4	5	4	5	.	.	4	5	6	3	.	0	.	.	.	.
April	.	5	5	.	3	5	6	2	6	6	.	.	3	.	.	.	6	6	6	6	6	5	6	5	7	.	3	2	.	.	—
Dry season.																															
May	.	.	.	.	1	3	.	5	2	.	.	.	5	5	4	5	5	2	6	1	2	.	6	5	.	.	.	.	.	.	.
June	.	.	3	6	3	.	.	5	4	3	.	5	.	.	6	3	5	.	.	.	.	4	.	2	5	7	5	.	1	6	—
July	4	3	4	2	6	5	1	5	.	.	.	.	.	.	.	.	3	0	5	.	.	.	.	.	.	.	.	2	.	4	.
August	.	.	3	.	3	.	.	.	5	5	6	4	3	3	6	3	.	.	.	.	.	3	2	.	.	3	2	.	3	4	4
September	.	6	5	.	.	2	.	1	.	2	5	5	.	.	.	5	2	.	4	3	.	2	.	.	.	0	3	7	2	4	—
October	.	.	2	.	5	5	5	4	1	.	7	6	5	7	3	6	.	.	3	.	.	5	5	4	4	7	.	.	.	3	2

TABLE 13.—*Frequency of various daily rain "grades." Apia, Samoa, 1902–1903.*

Season.	Number of days having daily "grade"										Totals.
	No rain.	0	1	2	3	4	5	6	7	8	
Wet season.											
November	11	0	0	3	5	1	4	6	0	0	81
December	17	1	3	0	1	4	2	3	0	0	50
January	8	0	0	2	5	4	5	4	3	0	105
February	7	0	2	0	5	3	5	1	4	1	96
March	15	1	2	0	2	3	5	3	0	0	63
April	10	0	0	2	3	0	5	9	1	0	99
Dry season.											
May	16	0	2	3	1	1	6	2	0	0	57
June	13	0	1	1	4	2	5	3	1	0	73
July	18	1	1	2	2	3	3	1	0	0	44
August	14	0	0	2	8	3	2	2	0	0	62
September	13	1	1	5	2	2	4	1	1	0	58
October	11	0	1	2	3	3	6	2	3	0	89
Year.	153	4	13	22	41	29	52	37	13	1	877
Wet season	68	2	7	7	21	15	26	26	8	1	494
Dry season	85	2	6	15	20	14	26	11	5	0	383
Seasonal ratio	0.80	1.00	1.17	0.47	1.05	1.07	1.00	2.36	1.60	∞	1.29

The same ratio, when computed from the hourly "grades," is 1.5, whereas the ratio from rain quantities measured in the customary "additive" manner is 1.8. It can safely be expected that a similar proportion will exist in other rain statistics.

Table 14 shows the average daily "grades" for each month of the eight different seasons observed. The "character" of each season is given below and shows distinctly the great variation from year to year. Only the daily "grades" for the rain days do not show remarkable features, the individual monthly average of the wet season varying between 3.5 and 5.0, and for the dry season between 2.4 and 4.4. The average values for the two seasons are 4.3 and 3.7 and characterize the seasonal difference very slightly.

WIND DIRECTIONS AND RAIN.

For the year 1906 the wind registrations are quite complete, and the statistics given in Table 15 have been obtained.

These percentages when divided by one hundred give the respective probabilities. Thus it appears that the tradewinds, during both seasons, afford a smaller rain probability than the

TABLE 14.—*The mean daily rain "grades" for each month of the period, November, 1902,—December, 1906, Apia, Samoa.*

Months.	For all days.						For the rain days.					
	1902–1903.	1903–1904.	1904–1905.	1905–1906.	1906.	Average Nov., 1902, to Oct., 1906.	1902–1903.	1903–1904.	1904–1905.	1905–1906.	1906.	Average Nov., 1902, to Oct., 1906.
Wet season.												
November	2.7	3.3	2.6	2.1	3.2	2.7	4.3	4.3	3.5	4.6	4.6	4.1
December	1.6	2.9	3.2	2.2	3.2	2.5	3.6	4.5	4.2	3.5	4.0	4.0
January	3.4	4.2	3.3	2.4	....	3.3	4.6	4.7	4.7	4.1	....	4.5
February	3.4	4.3	2.5	2.3	....	3.1	4.6	4.6	4.6	3.6	....	4.4
March	2.0	3.1	2.5	3.5	....	2.8	3.9	4.8	4.1	4.5	....	4.3
April	3.3	4.2	2.4	2.9	....	3.2	5.0	4.7	3.8	3.7	....	4.3
Dry season.												
May	1.8	2.2	0.5	2.2	....	1.7	3.8	3.6	2.4	4.2	....	3.7
June	2.4	1.5	1.4	2.7	....	2.0	4.3	3.8	3.9	4.2	....	4.1
July	1.4	1.8	1.0	2.1	....	1.6	3.4	4.2	3.2	3.8	....	3.7
August	2.0	2.2	1.6	2.3	....	2.0	3.6	3.7	3.8	3.5	....	3.6
September	1.9	2.4	1.4	1.6	....	1.8	3.4	3.4	4.1	3.5	....	3.5
October	2.9	2.0	1.6	2.2	....	2.2	4.4	3.8	3.6	3.4	....	3.8
Year.	2.4	2.8	2.0	2.4	....	2.4	4.1	4.2	3.9	3.9	....	4.1
Wet season	2.7	3.6	2.8	2.6	....	2.9	4.4	4.6	4.1	4.0	....	4.3
Dry season	2.1	2.0	1.3	2.2	....	1.9	3.9	3.7	3.6	3.8	....	3.7
Character:												
Wet season	(+0.12)	+0.25	+0.24	+0.19	....	....	(+0.05)	+0.08	+0.05	+0.04	....	....
Dry season	−0.18	−0.20	−0.32	(−0.07)	....	....	−0.06	−0.07	−0.06	(−0.03)	....	....

average of all winds. During the dry season a much higher rain probability is presented by the south to west-northwest winds, evidently because atmospheric disturbances are accompanied by these winds.

TABLE 15.—*Wind direction and rain.*

1906.	Wet months.			Dry months.		
Regardless of wind directions, rain hours, per cent of all hours	14.7			10.9		
Group of winds	NW to NE.	ENE to SSE	S to WNW	NW to NE	ENE to SSE	S to WNW
Winds, per cent of all winds	14.0	58.6	25.6	6.3	89.6	2.2
Rain hours, per cent of all rain hours	16.8	53.2	23.2	6.8	87.5	4.4
Rain hours, per cent of all hours of the special wind group	17.6	13.3	13.3	11.9	10.6	21.6

The northwest to northeast winds change remarkably from one season to the other. During the wet season they are the rain-bringing winds as they come from the high seas; but during the dry season they are dry and therefore seem in fact to be trade winds which are shifted by the sea breeze and come from the north.

WEATHER NOTES FROM PUERTO PLATA, DOMINICAN REPUBLIC.

By R. J. TOTTEN, U. S. Consul. Dated Puerto Plata, D. R., August 14, 1909.

The Tacajo Cacao and Sugar Company, whose banana plantation lies at Sosua in the province of Puerto Plata, has published from time to time a series of weather notes. From these notes the following summary for the fiscal year, July 1, 1908–June 30, 1909, has been compiled.

The total rainfall for this period was 110 inches, distributed as follows:

TABLE 1.—*Monthly rainfall at Puerto Plata, D. R.*, 1908–9.

1908.		1909.	
	Inches.		*Inches.*
July	6.75	January	20.90
August	1.45	February	8.35
September	19.75	March	1.85
October	6.90	April	1.35
November	12.90	May	8.05
December	13.85	June	7.90

The average monthly rainfall was 9.16 inches. The heaviest rainfall registered in any one day was 9.10 inches on September 10, 1908.

The highest temperature recorded during this period was 94° F., on July 12, 1908, the lowest was 62°, on January 19, 1909. The maximum and minimum temperatures recorded in each month follow:

TABLE 2.—*Monthly temperature extremes at Puerto Plata, D. R.*, 1908–9.

1908.	Max.	Min.	1909.	Max.	Min.
	°F.	*°F.*		*°F.*	*°F.*
July	94	77	January	81	62
August	93	80	February	80	70
September	92	73	March	86	71
October	86	78	April	86	74
November	85	76	May	87	74
December	84	72	June	87	70

The average mean temperature for the year was 79° F.

The prevailing winds are east-northeast and are commonly known as "Local Trades." Average velocity of wind 6 miles per hour.

The highest recorded barometer reading was 30.45 inches, the lowest was 28.25 inches.

CHANGES IN THE MONTHLY WEATHER REVIEW.

In the issues of the MONTHLY WEATHER REVIEW for February and March, 1909, we published in full all the pertinent parts of orders issued by the Chief of the U. S. Weather Bureau, outlining changes which he planned to make in the character of the REVIEW beginning with the issue for July, 1909. At the beginning of the announcement in the issue for February the following statement was made:

It appears from the following that those readers particularly interested in *climatological statistics* should request that the REVIEW be continued to their addresses; those who are more interested in theoretical and technical discussions of data should request that the Mount Weather Bulletin be sent them in place of the MONTHLY WEATHER REVIEW.

It appears that there are many who have not read these notices and outlines of prospective changes, and the Weather Bureau is still frequently requested to renew or add to its subscription list recipients who apparently do not realize the character of the new publications.

Our readers are therefore informed that beginning with the issue for July, 1909, the MONTHLY WEATHER REVIEW will be restricted to statistical tables of general climatological data for the whole of the United States. The relatively small amount of accompanying text will summarize the weather conditions of the month in the different districts. It is thus evident that hereafter the REVIEW will be of value only to those advanced students of climates, engineers, etc., who need detailed data for their own discussion.

Few papers of general interest to teachers, except as related to climatology, will be published in the MONTHLY WEATHER REVIEW, and it is not probable that the publication will be of value to those public schools and high schools that have been receiving it heretofore. These circles of readers must now turn to the editors of already existing journals to supply their needs along those lines formerly met, perhaps, by articles in the MONTHLY WEATHER REVIEW.

We may here also take the opportunity to remark that the scope of the articles appearing in the Mount Weather Bulletin will be limited to technical treatments of subjects of advanced research. This will make most of the articles of that publication also beyond the comprehension of the average pupil of the above grades of schools, and make the Bulletin only appropriate for the libraries of colleges and universities.—*C. A.*

TORNADOES IN MISSOURI.

On April 29 a very destructive tornado passed through Golden, Barry County, killing nineteen or twenty persons and injuring about eighteen others. Property amounting to nearly $20,000 was destroyed within the village and probably as much more along the route of the storm northeastward to Viola, Stone County, where two or three persons were killed and nine seriously hurt. A number of citizens saw the approaching storm and describe it as resembling the smoke of a railway engine. It was not accompanied by rain or hail. Nearly all the trees blown down by the tornado fell in the direction whence it came, the trees to the southwest being badly battered and bruised as usual. Chickens were picked of their feathers and some were torn to pieces. It is reported that the large amount of atmospheric electricity present increased the difficulties of telephoning to Golden.

Another tornado visited Alton, Oregon County, on this same date, destroying most of the buildings of the town and killing six persons.—*C. A., jr.*

TORNADO AT ANNISTON, ALA.

By W. F. CLARK, Assistant Observer. Dated Anniston, Ala., May 8, 1909.

On April 13, 1909, at about 3 a. m., a small tornado traversed Calhoun County, Ala., from southwest to northeast, passing

within two miles northwest of the regular observing station at Anniston, Ala. At that point there is a negro settlement of one-story houses, called "Camp Shipp," occupying the northerly and easterly ridges and the bottom of a small vale between hills to west, north, and east thereof. This vale is from forty to sixty rods wide between the crests of the ridges from east to west, and eighty rods long from north to south. It opens towards the southwest upon a tract of gently rolling farm land bare for a half mile or more to both west and south, while the enclosing ridges are depressed slightly at the northeast corner of the little vale. In the lowland along the base of the westerly wooded slopes the houses were not injured. Others, however, slightly farther to eastward were moved four or five feet from their foundations, carrying with them large brick-fireplace chimneys built up from the ground. Passing northeastward, the tornado unroofed buildings here and there for six miles or farther.

One man, living next east of the Wilson house, was just returning from work, and was on the Buttermilk Road only ten rods east of the tornado vortex when it struck the Wilson house and crossed the road in front of him. He was running directly into the vortex to get to his home, and to get out of the rain, which came down with great intensity and suddenness close to the storm center. The tornado approached from the south with a roar, "like a freight train crossing a bridge," and passed to northeast out of hearing. He was at first blown across the road to the fence by a violent blast of wind from the south. This was followed almost immediately by violent atmospheric surges from the west, which continued for some time. Between these blasts he rose from the ground, ran across to the south side of the road and clung to his fence, working his way along a couple of rods to the gateway and to the verandah a couple of steps back, where he stood for some minutes afraid to open the doorway through fear that his house might be unroofed. He observed no hail. There was much thunder and lightning. Owing to the darkness and his exciting experiences he did not observe whether there was a funnel cloud. No one was injured.

At this station, two miles to the southeast, the highest wind velocity was 31 miles from the southwest at 2:48 to 2:53 a. m. At this time the reduced barometer reading, which had been 29.78 inches for two hours, rose ten hundredths of an inch in fifteen minutes. The temperature rose slowly from 63° at 11 p. m. on the 12th to 66° at 2:40 a. m. on the 13th, and then fell to 53° in fifteen minutes. Precipitation had been very light, barely sprinkling or misting from 3:45 p. m. on the 12th till 2:40 a. m. on the 13th, but fell at an excessive rate from 2:40 to 2:46 a. m., heavy till 3:30, and light till 7:45 a. m. Moderate to brisk southeast winds had prevailed for two days, but with the passage of the vortex the winds changed from southeast at 2:47 a. m. to south, southwest, and west in five minutes and to northwest in nineteen minutes, diminishing rapidly thereafter to light after 3:30 a. m.

During the passage of this tornado up the little vale between the hills of Camp Shipp, its path for eighty rods was due north. Along this path the wind effects indicate that the vortex was characterized by two violent wind forces at right angles to each other, one from the south on the right of the vortex, and the other from the west just in rear of the vortex, both of them surging in violent waves and performing the destructive work that levelled trees and buildings. It would thus appear that the southeast wind that prevails before tornadic storms feeds into the front of the tornadic vortex in a steady stream that does no destructive work, while the northwest wind that prevails after the tornado has passed by feeds into the vortex in violent surging, destructive waves, as a west wind just in rear, as a south wind just on the right of the vortex, and as an east wind on the immediate vortex front. Combining here with the southeast wind on its right, the two rise into the vortex as a surging easterly lifting wind of greatly increased force by virtue of the doubling up of the two inflowing wind streams.

DESTRUCTIVE STORMS IN ALABAMA.

By E. C. Horton, Assistant Observer. Dated Montgomery, Ala., June 22, 1909.

April, 1909.

A violent windstorm occurred on April 30, 1909, in Calhoun County, between 4:30 and 5 p. m. The most damage was caused at Piedmont where the storm appeared as "a rapidly moving, black, low-hanging cloud" with a very high wind from the southwest, rather than a funnel-shaped cloud with a cyclonic whirl. The path of destruction was about one hundred yards wide, but the damage almost entirely confined to Piedmont. Property loss was about $4,000, but no person seriously injured. The resident observer reports that the local topography renders Piedmont liable to high winds over this same path.

About 8 p. m. of the same day a typical tornado passed within one mile of Delta, Clay County, having started four miles west of Pyriton in what is known as Shinbone Valley. The path was ten miles long, toward the northeast, and one-fourth to three-fourths mile wide. Owing to the sparsely settled condition of the country the number of injured persons was but seven, and the property loss did not exceed $6,000.

May, 1909.

A tornado occurred in Escambia County, Ala., on May 25, 1909. The storm seems to have been at its worst about 3 a. m. Its path of destruction has been estimated from one-half to 3 miles in width, and about 7 miles long. It seems probable, however, that it came from much farther to the northwest, violent windstorms having been reported the same night or the preceding afternoon at Eutaw, Greene County, and Demopolis, Marengo County; also over a portion of the country lying between Myrtlewood and Linden, Marengo County, as well as at Jones Mill, Monroe County. These places lie in an irregular line northwest and southeast. The places of greatest damage appear to have been Herrington, where the school house was demolished; Hammac, where a church and several houses were blown from their foundations; and the vicinity of Pollard, where much destruction to timber was wrought.

The storm had the usual funnel-shape cloud in at least a part of its course. No loss of life or serious injury to persons was reported from any points in the affected district. The storm was last heard of at Bradley, on the eastern border of Escambia County. At this point the rains, that were heavy throughout the affected district, became a cloudburst.

An accurate estimate of the property loss is not obtainable, but must have been not less than $10,000 or $15,000.

A tornado traversed a considerable portion of Madison and Morgan Counties, in north Alabama, about 5 p. m., May 30, 1909. The storm first struck Cedar Lake, a suburb of Decatur, Ala., where a large congregation were assembled at the colored church. The church was lifted from its foundation and turned completely around. No one was injured, except by being bruised in the mad scramble to get out of the building. Many trees were uprooted and houses were unroofed, and the accompanying rainfall was torrential. At Triana, east of Decatur, several residences were blown down, and both churches badly damaged. Considerable damage to trees, roofs, wires, etc., was done at Huntsville, although the severest part of the storm appears to have passed some distance from that place. At Ryland a church and some other property was damaged. The tornado was last reported at Brownsboro. There a church was lifted from its foundation and lowered to the ground without serious damage to the building. The greatest loss seems to have been to orchards, groves, and fields. While a great many buildings were demolished or damaged, they were

generally of an inexpensive kind, or else the damage was of a minor nature.

The tornado travelled a distance of about 40 miles, and its track was about one-fourth of a mile wide. No deaths or serious injuries resulted.

DESTRUCTIVE STORMS IN MICHIGAN.

By C. F. Schneider, Section Director. Dated May 29, 1909.

During the afternoon of Saturday, May 15, 1909, thunderstorms with high winds were general throughout southern Michigan, and a large amount of damage was done to buildings and trees. About 3:15 p. m. a destructive windstorm occurred at Fowlerville, Livingston County, and over the surrounding country for a distance of 2 to 4 miles. It is estimated that about two hundred and fifty buildings were more or less damaged, many being unroofed and several demolished. The total damage is estimated at about $50,000.

Three persons were injured by flying débris or being thrown to the ground by the wind, and as a result of fright one woman died from heart disease. About twenty-five families were rendered homeless.

The path of greatest destruction was about six rods wide and extended from southwest to northeast. One observer reports that the storm had a well defined funnel-shaped cloud, but the fact that uprooted trees lay in the same direction on all sides of its path, as reported by the same observer, would indicate that the storm was not a true tornado with rotary winds.

On the same date severe thunderstorms visited other points in southern Michigan, causing much damage to fruit trees and other property. At Cadillac one person was struck by lightning, and the power plant disabled at Flint. At Albion a tall chimney was blown down upon a church, causing $1,000 damage but no loss of life. At Eaton Rapids and vicinity the wind caused damage to the extent of $1,000.

CORRIGENDA.

In the Monthly Weather Review, March, 1909, p. 103, col. 2. line 20 from the bottom, for "Berlin. 1875" read "Berlin, 1879;" on p. 104, col. 1, last entry, for "Lavel" read "Laval," in col. 2, line 2 from the bottom, for "1830" read "1880;" on p. 107, col. 1, for "Houdailles" read "Houdaille;" on p. 109. col. 1, for "Greeley" read "Greely."

THE WEATHER OF THE MONTH.

By Mr. P. C. Day, Acting Chief, Climatological Division.

PRESSURE AND WINDS.

The distribution of the mean atmospheric pressure for May, 1909, over the United States and Canada is graphically shown in Chart VI, and the average values and departures from the normal are shown for each station in Tables I and III.

Barometric depressions of wide extent, central in the upper and lower Mississippi valleys during the closing days of April, moved, the former into Canada and the latter to the Atlantic seaboard, during the 1st and 2d.

Considerable depressions also covered the eastern districts from the 8th to 10th and again from the 25th to 27th, aside from which no depression of marked extent crossed the United States, although the month was one of generally low barometric pressure from the Rocky Mountains eastward, the departure from the normal averaging about −.05 inch over nearly all the above-named region. From the Rocky Mountain districts westward to the Pacific the pressure was comparatively high, the departure above the normal increasing to from +.05 to +.07 inch on the coasts of Washington and Oregon.

From April to May the mean pressure decreased in all portions of the United States and Canada, the amount ranging uniformly from about −.08 to −.14 inch.

Southerly winds were dominant over the Gulf States and Mississippi Valley, while under the influence of comparatively high barometric pressure on the Pacific coast the winds over the Plateau and Rocky Mountain districts were northwesterly and westerly.

Compared with the normal there was a general increase in the wind velocity in practically all districts, a few points only in the southern portion of the great Plains and in the Middle Plateau region showing wind movement slightly less than the average.

TEMPERATURE.

Following the low areas covering the eastern districts at the beginning of the month an extensive area of cold weather overspread the central valleys, moving eastward and southward during the 2d and 3d. Freezing temperatures and frosts occurred from central Texas northeastward to the lower Lakes with snow in the upper Lake region. During the following few days the temperature rose rapidly over all eastern districts, but cool weather continued over the northwestern and Mountain districts during most of the first decade. Cold weather again overspread the Mississippi Valley and eastern districts from the 10th to 13th, with frost in the Lake region, upper Ohio Valley, and in the interior and mountain portions of the Middle and North Atlantic States.

Generally cool weather was the rule during the 2d and 3d decades of the month, and as a whole the mean temperature for the month was below the normal in practically all portions of the United States, except over southern Florida and at a few points along the immediate Atlantic coast. The month was unusually cold over the Rocky Mountain and Plateau regions, and at its close the advance of the season had been seriously delayed thereby.

Maximum temperatures were not unusually high at any period during the month. They ranged from 80° to 90° over the eastern districts; from 90° to 97° over the central and southern portions of the Great Plains; and from 100° to 106° in the interior and lower valleys of Arizona and California.

Minimum temperatures were in many districts unusually low, especially over the regions west of the Rocky Mountains where severe frosts were of frequent occurrence, doing considerable damage to fruits, etc., but much less than would have been the case had not the development of vegetation been retarded by the continued cold weather preceding.

PRECIPITATION.

Rain in sufficient quantities and well distributed during the month occurred in all districts east of the Rocky Mountains, except over portions of the Middle Atlantic States, where there was a general lack of precipitation from the latter part of April until late in May. Over the greater part of Texas copious showers occurred, greatly relieving a serious drought that had prevailed over that State during the preceding months and which had given much concern to the cotton interests. West of the Rocky Mountains the month was one of generally deficient rainfall, especially so in portions of New Mexico, California, and the central portions of the Plateau region.

Rainfall was much above the normal amount over large sections of the middle Gulf States. In portions of central Mississippi and the adjoining districts of Alabama, Louisiana, and Arkansas, the precipitation during the latter part of the month was in some cases the heaviest recorded at the respective

stations. Rapid rises occurred in many of the local streams and much damage resulted to bridges, roads, crops, etc. Heavy falls also occurred in the Black Hills region of South Dakota and in portions of northeastern Oklahoma, considerable damage resulting from washing away of bridges, etc.

SNOWFALL.

Small amounts of snowfall occurred over the more northern districts of the eastern half of the country, and generally throughout the mountain regions of the west. In northern Michigan amounts exceeding 5 inches were recorded at several points, and some heavy falls were reported locally in the mountains of western Montana.

The large accumulation of snowfall in the high mountains of the west, especially in the central and northern districts, remained nearly intact, due to the prevailing cool weather. In the more southern districts, however, considerable melting occurred, and many of the rivers and streams in that section were at flood stages during the greater part of the month.

The large amount of snow in the mountains and its generally well-packed and frozen condition insure an abundant supply of water for the coming agricultural season.

HUMIDITY AND SUNSHINE.

The percentage of relative humidity was well above the normal over most of the territory between the Appalachian Mountains and the Mississippi Valley and over most of the northern portion of the country. From the middle Mississippi Valley westward to the Pacific, including the greater part of Texas and the southwest, there was a general deficiency in the relative humidity, amounting to from 10 to 15 per cent in portions of western Texas and northern California.

The percentage of sunshine was generally less than the average over nearly all districts east of the Rocky Mountains and over portions of the northern mountain and Plateau districts. Over the remaining districts west of the Rocky Mountains there was generally an abundance of sunshine, the percentage ranging from 80 to 95 per cent of the possible in portions of the southwest.

LOCAL STORMS.

A severe tornado occurred at Zephyr in Brown County, Tex., on May 30, resulting in the death of 28 persons, the injuring of many more, and the loss of much property.

Tornadoes occurred also in Kansas on the 5th, 14th, and 29th and in North Dakota also on the last-named date, resulting in the loss of several lives, the injuring of many persons, and considerable damage to property.

Average temperatures and departures from the normal.

Districts.	Number of stations.	Average temperatures for the current month.	Departures for the current month.	Accumulated departures since January 1.	Average departures since January 1.
		°	°	°	°
New England	12	53.6	− 0.9	+ 4.1	+ 0.8
Middle Atlantic	16	61.6	− 0.1	+10.9	+ 2.2
South Atlantic	10	69.0	− 0.8	+10.9	+ 2.2
Florida Peninsula *	8	76.2	+ 0.2	+14.2	+ 2.8
East Gulf	11	70.0	− 2.3	+ 6.4	+ 1.3
West Gulf	10	70.9	− 1.7	+ 7.7	+ 1.5
Ohio Valley and Tennessee	13	63.1	− 2.2	+ 7.2	+ 1.4
Lower Lake	10	55.0	− 2.2	+ 4.9	+ 1.0
Upper Lake	12	50.8	− 1.4	+ 4.0	+ 0.8
North Dakota *	9	51.5	− 1.9	− 3.9	− 0.8
Upper Mississippi Valley	15	59.4	− 2.5	+ 2.8	+ 0.6
Missouri Valley	12	59.8	− 2.2	+ 3.2	+ 0.6
Northern Slope	9	50.0	− 3.0	− 4.7	− 0.9
Middle Slope	6	60.6	− 2.4	+ 1.3	+ 0.3
Southern Slope *	7	68.5	− 1.3	+ 6.8	+ 1.4
Southern Plateau *	12	61.8	− 2.6	− 5.0	− 1.0
Middle Plateau *	10	52.4	− 2.4	+ 0.7	+ 0.1
Northern Plateau *	12	51.7	− 3.1	− 1.5	− 0.3
North Pacific	7	50.9	− 2.3	− 6.3	− 1.3
Middle Pacific	8	58.0	− 1.5	+ 1.3	+ 0.3
South Pacific	4	60.2	− 1.4	+ 0.4	+ 0.1

* Regular Weather Bureau and selected cooperative stations.

In Canada.—Director R. F. Stupart says:

The mean temperature of May was somewhat in excess of the average in northwestern New Brunswick, northern Manitoba, and in parts of northern and western Saskatchewan, and below the average in other portions of the Dominion; the largest negative departures, from 3° to 4°, occurred in the more central counties of Ontario and in British Columbia. These conditions following a rather cold April led to vegetation being backward in nearly all parts of the Dominion.

The rainfall of the month was somewhat excessive in Quebec and in southern and eastern Ontario and over most of Nova Scotia; also in Alberta and southern Saskatchewan, while in nearly all other districts there was a deficiency, which on Vancouver Island and in Ontario north of the Great Lakes was fairly pronounced.

Average precipitation and departures from the normal.

Districts.	Number of stations.	Average.		Departure.	
		Current month.	Percentage of normal.	Current month.	Accumulated since Jan. 1.
		Inches.		Inches.	Inches.
New England	12	2.83	85	− 0.5	+ 2.5
Middle Atlantic	16	3.58	100	0.0	− 0.6
South Atlantic	10	3.94	134	+ 1.0	− 2.5
Florida Peninsula *	8	4.67	121	+ 0.8	− 1.8
East Gulf	11	5.93	168	+ 2.4	+ 5.1
West Gulf	10	4.14	100	0.0	− 5.4
Ohio Valley and Tennessee	13	3.98	108	+ 0.3	+ 2.7
Lower Lake	10	3.82	122	+ 0.7	+ 4.0
Upper Lake	12	2.23	67	− 1.1	+ 1.2
North Dakota *	9	4.66	189	+ 2.2	+ 0.3
Upper Mississippi Valley	15	3.96	95	− 0.2	+ 2.9
Missouri Valley	12	4.81	114	+ 0.6	+ 1.1
Northern Slope	9	2.33	100	0.0	− 0.7
Middle Slope	6	3.25	84	− 0.6	− 1.5
Southern Slope *	7	2.09	66	− 1.1	− 4.0
Southern Plateau *	12	0.11	18	− 0.5	− 1.2
Middle Plateau *	10	0.49	41	− 0.7	− 0.3
Northern Plateau *	12	1.31	77	− 0.4	− 0.8
North Pacific	7	2.01	77	− 0.6	− 1.4
Middle Pacific	8	0.16	14	− 1.0	+ 6.9
South Pacific	4	T.	0	− 0.6	+ 5.2

* Regular Weather Bureau and selected cooperative stations.

Maximum wind velocities.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
Amarillo, Tex	8	52	nw.	Oklahoma, Okla	14	50	s.
Block Island, R. I	22	53	ne.	Pierre, S. Dak	5	62	nw.
Do	23	52	ne.	Pittsburg, Pa	2	56	w.
Buffalo, N. Y	1	52	sw.	Pocatello, Idaho	5	53	sw.
Do	2	60	sw.	Point Reyes Light, Cal	5	50	nw.
Canton, N. Y	2	50	sw.	Do	8	68	nw.
Cheyenne, Wyo	5	50	nw.	Do	9	76	nw.
Chicago, Ill	15	50	sw.	Do	10	65	nw.
Columbus, Ohio	8	50	nw.	Do	11	68	nw.
Detroit, Mich	1	54	w.	Do	17	67	nw.
Duluth, Minn	6	51	ne.	Do	18	50	nw.
El Paso, Tex	28	50	w.	Do	19	71	nw.
Galveston, Tex	26	60	sw.	Do	20	68	nw.
Lewiston, Idaho	4	52	w.	Do	21	60	nw.
Lincoln, Nebr	5	52	nw.	Do	23	56	nw.
Memphis, Tenn	9	56	nw.	Do	25	62	nw.
Minneapolis, Minn	6	50	w.	Do	27	58	nw.
Modena, Utah	27	56	sw.	Rapid City, S. Dak	28	52	sw.
Mount Tamalpais, Cal	4	51	nw.	Richmond, Va	1	53	s.
Do	8	58	nw.	Roswell, N. Mex	8	50	n.
Do	9	74	nw.	St. Paul, Minn	6	50	nw.
Do	10	68	nw.	Sioux City, Iowa	1	56	nw.
Do	20	72	nw.	Do	5	51	nw.
Do	21	71	nw.	Do	6	63	nw.
Do	26	52	nw.	Do	11	53	s.
Do	27	72	nw.	Do	29	52	sw.
Do	28	62	nw.	Springfield, Mo	14	64	s.
Mount Weather, Va	10	56	nw.	Tatoosh Island, Wash	30	53	s.
Do	11	51	nw.	Toledo, Ohio	1	50	sw.
Nantucket, Mass	22	57	ne.	Do	15	50	sw.
Norfolk, Va	1	56	sw.	Valentine, Nebr	30	54	nw.
North Head, Wash	29	50	se.	Vicksburg, Miss	25	52	nw.
Do	30	62	se.	Williston, N. Dak	29	52	nw.

Average cloudiness and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England	6.0	+ 0.5	Missouri Valley	5.0	− 0.1
Middle Atlantic	5.3	+ 0.3	Northern Slope	5.7	+ 0.2
South Atlantic	4.9	+ 0.4	Middle Slope	4.7	− 0.2
Florida Peninsula	4.4	0.0	Southern Slope	3.8	− 0.6
East Gulf	5.3	+ 0.6	Southern Plateau	2.0	− 0.7
West Gulf	4.7	− 0.1	Middle Plateau	4.0	− 0.1
Ohio Valley and Tennessee	5.5	+ 0.5	Northern Plateau	5.5	+ 0.4
Lower Lake	5.6	+ 0.2	North Pacific	5.9	− 0.4
Upper Lake	5.7	+ 0.2	Middle Pacific	3.1	− 1.0
North Dakota	5.3	− 0.2	South Pacific	3.9	− 0.2
Upper Mississippi Valley	5.3	0.0			

Average relative humidity and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England	75	− 3	Missouri Valley	62	− 3
Middle Atlantic	67	− 5	Northern Slope	61	+ 3
South Atlantic	73	− 1	Middle Slope	56	− 5
Florida Peninsula	78	+ 2	Southern Slope	47	− 9
East Gulf	74	− 3	Southern Plateau	32	0
West Gulf	74	− 1	Middle Plateau	41	− 5
Ohio Valley and Tennessee	69	+ 1	Northern Plateau	53	− 3
Lower Lake	73	+ 2	North Pacific	76	0
Upper Lake	72	0	Middle Pacific	64	− 2
North Dakota	67	+ 5	South Pacific	67	− 2
Upper Mississippi Valley	65	− 3			

CLIMATOLOGICAL SUMMARY.

By Mr. P. C. Day, Acting Chief, Climatological Division.

TEMPERATURE AND PRECIPITATION BY SECTIONS, MAY, 1909.

In the following table are given, for the various sections of the Climatological Service of the Weather Bureau, the average temperature and rainfall, the stations reporting the highest and lowest temperatures with dates of occurrence, the stations reporting the greatest and least monthly precipitation, and other data, as indicated by the several headings.

The mean temperatures for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperature and precipitation are based only on records from stations that have ten or more years of observations. Of course the number of such records is smaller than the total number of stations.

Section.	Temperature—in degrees Fahrenheit.								Precipitation—in inches and hundredths.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
Alabama	68.6	− 2.8	Pushmataha	93	24	Maple Grove	30	1	6.51	+ 3.04	Spring Hill	12.27	Cordova	3.47
Arizona	66.0	− 2.6	3 stations	106	30, 31	St. Michaels	18	1	0.03	− 0.27	Williams	0.48	39 stations	0.00
Arkansas	67.0	− 2.8	Spielerville Pocahontas	92 92	5 29	Bergman Mammoth Spring	28 28	1, 2 2	6.76	+ 1.49	Arkansas City	10.64	Black Rock	4.03
California	60.4	− 1.6	Indio, Mecca	109	31	Tamarack	11	19, 22	0.23	− 1.02	Monumental	4.10	128 stations	0.00
Colorado	49.0	− 3.0	Lamar Holly	92 92	28 29	Whitepine	− 5	1	1.36	− 0.62	Corona	5.16	River Portal	T.
Florida	74.9	− 1.1	Ocala Orange City	99 99	28 27	Fenholloway	40	4	4.13	+ 0.27	Jupiter	8.61	Cedar Keys	0.72
Georgia	69.7	− 2.4	Valdosta	100	27	Lafayette	31	2	4.43	+ 0.96	Clayton	10.60	Valona	1.40
Hawaii (April)	69.1	......	Kalawao, Molokai	93	27	Humuula, Hawaii	32	1	6.61	......	Waikaumalo, Hawaii	27.69	Humuula, Hawaii	0.40
Idaho	50.2	− 2.8	Orofino	96	31	Lake	8	21	1.60	− 0.22	Sugar	4.83	Garnet	0.15
Illinois	60.3	− 2.3	Monmouth	93	5	Lanark	25	3, 4	4.01	− 0.20	Griggsville	7.50	Antioch	1.05
Indiana	59.9	− 2.7	Rome	91	29	Lima	28	2	4.70	+ 1.04	Madison	7.36	Elkhart	2.70
Iowa	57.9	− 2.2	Onawa	97	5	Inwood	18	2	4.34	− 0.16	Rockwell City	7.85	Waterloo	1.86
Kansas	62.2	− 2.1	Liberal	106	29	Wallace	14	1	3.86	− 0.38	Grenola	8.13	Oberlin	0.55
Kentucky	64.0	− 1.7	Earlington	93	18	Greensburg	27	2	4.63	+ 0.69	Mount Sterling	9.51	Hopkinsville	2.75
Louisiana	72.3	− 1.5	Lake Charles Schriever	96 96	24 30	Robeline	34	2	5.85	+ 1.43	Newellton	12.38	Lakeside	1.22
Maryland and Delaware	62.3	− 0.4	Cambridge, Md.	98	7	Deer Park, Md	22	12	3.60	− 0.23	Annapolis, Md.	5.23	Green Spring Furnace, Md.	2.03
Michigan	52.4	− 1.4	West Branch	90	29	Gaylord	12	10	2.45	− 0.87	Morenci	4.80	Humboldt	0.62
Minnesota	53.2	− 1.4	Albert Lea Winnebago	95	5	Pine River Dam	4	1, 2	3.36	− 0.15	Lynd No. 2	7.12	Pokegama Falls	0.88
Mississippi	69.2	− 3.0	3 stations	92	3 d't's	Ripley	32	2	9.95	+ 6.11	Yazoo City	19.24	Pearlington	4.76
Missouri	63.3	− 1.9	Warsaw, Maryville	96	5	3 stations	25	1, 2	5.34	+ 0.39	Gano	9.02	Oregon	1.85
Montana	48.2	− 2.3	Tokna	90	4	Garneil	5	2	2.42	− 0.27	Reese Creek	7.26	Plains	0.15
Nebraska	57.6	− 1.8	Lynch, PawneeCity	100	5	Lexington	10	1	3.23	− 0.41	Santee	8.44	Bloomington	0.30
Nevada	52.8	− 1.7	Logan	100	31	Cobre	10	6	0.18	− 0.81	San Jacinto	1.51	6 stations	0.00
New England*	53.7	− 1.5	St. Johnsbury, Vt. Norwalk, Conn.	87 87	10 15	West Ossipee, N.H	22	5	3.02	− 0.36	Cornwall, Vt.	5.74	Van Buren, Me.	1.00
New Jersey	60.0	− 0.6	Indian Mills	91	15	Layton	27	3	2.30	− 1.71	Cape May	4.84	River Vale	0.70
New Mexico	57.5	− 3.3	Deming	98	28	Fort Union	10	4	0.62	− 0.37	Dorsey	4.31	13 stations	0.00
New York	55.0	− 1.1	Bedford West Point	88 88	6 7	Indian Lake	18	3	3.69	+ 0.11	Blue MountainLake	6.69	Hunt Salisbury Mills	1.69 1.62
North Carolina	65.9	− 1.8	Weldon	94	7	Banners Elk	25	3	5.36	+ 1.03	Murphy	10.47	Beaufort	1.22
North Dakota	51.0	− 2.0	Coal Harbor	98	5	Minto	5	1	4.29	+ 1.88	Medora	8.60	Portal	2.33
Ohio	58.7	− 2.4	Amesville	91	31	Medina	24	2	4.72	+ 1.09	Tiffin	7.78	Millport	2.00
Oklahoma	67.1	− 1.5	Hobart	101	5	Hooker	19	1	5.49	+ 0.45	Chandler	10.33	Chattanooga	0.25
Oregon	51.8	− 2.4	Grants Pass	96	31	Range	12	10	1.79	− 0.38	Glenora	6.93	Blalock	0.05
Pennsylvania	59.2	− 0.5	Gettysburg	92	15	Montrose	23	3	2.90	− 1.09	Hamburg	5.52	Pittsburg	1.52
Porto Rico	77.6	+ 0.1	Bayamon	97	24	Las Marias	55	3	6.17	− 1.83	La Carmelita B.	13.26	Manati	1.01
South Carolina	69.5	− 1.7	Florence	100	30	Spartanburg	35	2	4.76	+ 1.03	Greenville	8.89	Charleston	1.56
South Dakota	54.8	− 1.1	Elk Point	98	5	Deadwood	2	1	4.85	+ 1.19	Greenmount	13.96	Gannvalley	2.04
Tennessee	65.5	− 1.7	Decatur, Harriman	91	29	Erasmus	25	2	5.82	+ 1.91	Charleston	10.53	Springdale	1.50
Texas	72.9	− 1.1	Llano Grande, Zapata.	108	24	Tulia	15	1	3.06	− 0.67	Port Laraca	13.77	Marfa	0.00
Utah	52.6	− 3.2	St. George	92	5, 26	Loa	10	12, 14	1.02	− 0.38	Schofield	3.34	4 stations	0.00
Virginia	63.1	− 1.2	Nokesville	99	18	Burkes Garden	25	2.12	4.37	+ 0.32	Radford	8.80	Marion	2.42
Washington	53.4	− 2.2	Zindel	95	31	Davenport	20	11	1.82	− 0.62	Quiniault	7.65	Wahluke	0.00
West Virginia	60.8	− 1.5	Williamson	93	6	Nuttallburg	21	2	3.82	− 0.46	Princeton	6.05	Parsons	1.80
Wisconsin	52.4	− 3.4	Neillsville Prairie du Chien	92 92	5 6	Koepenick	10	4	2.40	− 1.47	Valley Junction	5.33	Racine	0.83
Wyoming	45.0	− 3.1	Gillette	90	4	Lake, Y. N. Park	0	6	2.13	− 0.24	Hunters Station	6.26	Basin	0.20

*Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.

DESCRIPTION OF TABLES AND CHARTS.

By Mr. P. C. Day, Acting Chief, Climatological Division.

For description of tables and charts see page 34 of Review for January, 1909.

TABLE I.—*Climatological data for U. S. Weather Bureau stations, May, 1909.*

Stations.	Elevation of instruments: Barometer above sea level, feet.	Elevation of instruments: Thermometers above ground.	Elevation of instruments: Anemometer above ground.	Pressure, in inches: Actual, reduced to mean of 24 hours.	Pressure, in inches: Sea level, reduced to mean of 24 hrs.	Pressure, in inches: Departure from normal.	Temperature of the air, in degrees Fahrenheit: Mean max. + mean min. ÷ 2.	Temperature: Departure from normal.	Temperature: Maximum.	Temperature: Date.	Temperature: Mean maximum.	Temperature: Minimum.	Temperature: Date.	Temperature: Mean minimum.	Temperature: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches: Total.	Precipitation: Departure from normal.	Precipitation: Days with .01, or more.	Wind: Total movement, miles.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
New England.							53.6	− 0.9										75	3.83	− 0.5										6.0	
Eastport	76	67	85	29.83	29.92	− .04	48.7	+ 1.8	69	30	56	34	1	42	25	44	41	79	1.56	− 2.2	13	8,410	s.	42	ne.	29	3	13	15	7.0	
Greenville	1,070	6		28.77	29.94		46.6		74	27	57	26	7	36	42				2.72		15		se.								
Portland, Me	103	81	117	29.82	29.94	− .03	51.4	− 2.1	74	6	58	31	1	44	32	46	41	72	2.95	− 0.7	15	6,840	e.	36	nw.	12	6	10	15	6.4	T.
Concord	288	70	79	29.63	29.94	− .04	53.2	− 2.5	78	14	64	31	1	42	41				1.35	− 1.9	12	4,530	se.	25	nw.	11	16	4	11	4.8	
Burlington	404	11	48	29.48	29.92	− .05	52.6	− 1.3	77	9	61	34	12	44	32				5.58	+ 2.8	15	7,848	s.	40	s.	10	6	7	18	6.9	T.
Northfield	876	16	70	28.99	29.94	− .03	50.8	− 2.7	77	10	61	31	26	41	40	46	41	71	3.54	+ 0.7	18	6,915	s.	37	nw.	30	3	11	17	7.3	T.
Boston	125	115	188	29.80	29.94	− .04	55.8	− 0.8	83	6	63	38	1	48	33	50	46	76	2.33	− 1.2	14	8,143	e.	32	ne.	22	6	10	15	6.5	
Nantucket	12	14	90	29.91	29.92	− .07	52.7	− 0.3	72	14	59	40	25	47	21	49	47	85	4.32	+ 1.6	9	13,120	sw.	57	ne.	22	9	14	8	5.5	
Block Island	26	11	46	29.92	29.93	− .07	52.7	− 0.2	72	15	58	40	1	48	19	49	47	84	3.26	− 0.5	12	12,749	sw.	53	ne.	22	15	4	12	4.7	
Narragansett		9					53.8	− 0.9	80	15	62	37	5	46	32				4.06		16		sw.				17	3	11		
Providence	160	141	165	29.77	29.95	− .03	56.4	− 2.1	84	6	66	38	1	47	39	49	43	68	2.09	− 1.4	15	7,889	nw.	36	nw.	30	9	11	11	5.7	
Hartford	159	122	140	29.76	29.93	− .05	57.5	0.0	84	6	67	36	1	48	32	51	47	72	1.99	− 1.6	16	6,190	s.	40	s.	3	8	8	15	6.3	
New Haven	106	116	155	29.81	29.93	− .06	57.4	− 0.2	83	31	66	38	2	48	32	51	45	67	2.19	− 1.4	18	7,262	s.	38	ne.	22	11	11	9	5.1	
Mid. Atlantic States.							61.6	− 2.1										67	3.58	0.0										5.3	
Albany	97	102	115	29.82	29.93	− .05	57.8	− 1.1	81	6	67	36	2	49	32	51	45	65	2.72	− 0.3	16	6,173	s.	32	s.	10	11	11	9	5.1	
Binghamton	871	78	90	29.00	29.93	− .03	56.2	− 0.8	81	6	66	35	1	47	37				2.47	− 0.6	14	4,874	nw.	33	sw.	2	6	6	19	7.1	T.
New York	314	108	350	29.59	29.93	− .06	60.4	+ 1.1	83	14	68	40	2	53	25	53	48	71	1.72	− 1.5	11	9,169	ne.	48	ne.	22	7	11	13	6.0	
Harrisburg	374	94	104	29.54	29.94	− .04	62.0	+ 0.3	89	15	71	38	2	52	33	53	45	59	2.40	− 1.3	8	5,470	w.	34	sw.	3	8	13	10	5.7	
Philadelphia	117	116	184	29.82	29.95	− .04	63.2	+ 1.0	89	15	72	42	2	54	28	55	48	64	2.67	− 0.5	7	8,164	nw.	33	nw.	11	10	11	10	5.4	
Scranton	805	111	119	29.08	29.94	− .04	58.4	− 0.4	83	6	68	36	2	49	35	51	44	62	4.28	+ 0.8	12	4,455	sw.	30	w.	2	7	12	12	5.8	T.
Atlantic City	52	37	48	29.88	29.94	− .04	58.6	+ 1.1	85	16	65	42	2	52	26	54	50	77	4.13	+ 1.1	6	7,315	sw.	38	ne.	22	6	11	14	6.2	
Cape May	17	48	52	29.94	29.95	− .01	59.5	+ 0.9	82	16	65	45	2	54	22	55			4.84	+ 1.8	7	7,349	s.	36	ne.	22	8	14	9	5.3	
Baltimore	123	100	113	29.81	29.94	− .05	64.5	+ 0.3	90	15	74	41	2	55	32	57	51	66	4.59	+ 1.0	7	5,815	sw.	31	se.	3	11	8	12	5.4	
Washington	112	62	85	29.82	29.93	− .07	64.4	+ 0.2	90	15	75	36	3	54	36	56	49	62	3.77	− 0.1	11	5,581	nw.	33	nw.	7	14	9	8	4.8	
Cape Henry	18	9	58	29.93	29.95	− .05	65.5	+ 1.3	88	7	74	48	3	57	29				3.86	− 0.2	10	10,842	sw.	48	sw.	1	16	6	9		
Lynchburg	681	83	88	29.22	29.96	− .04	64.2	− 1.7	90	7	76	36	3	52	39	58	53	70	4.58	+ 0.6	10	3,643	nw.	23	s.	3	11	13	7	5.5	
Mount Weather	1,725	10	54	28.13	29.93	− .07	59.2	− 0.3	82	15	68	31	2	51	25	51	45	65	2.99	− 0.8	10	10,271	nw.	56	nw.	10	8	16	7	5.4	
Norfolk	91	102	111	29.86	29.96	− .04	66.0	− 0.2	89	7	75	46	2	57	31	60	56	75	4.20	+ 0.1	11	7,468	s.	56	sw.	1	16	5	10	4.5	
Richmond	144	145	153	29.81	29.96	− .03	66.0	− 1.3	90	7	76	40	3	56	34				3.41	− 0.4	9	6,999	se.	53	s.	1	13	9	9	4.7	
Wytheville	2,293	40	47	27.60	29.94	− .05	59.2	− 2.2	83	31	71	31	3	47	38	53	48	72	4.65	+ 0.7	11	3,779	w.	21	w.	28	21	4	6	3.0	T.
S. Atlantic States.							69.0	− 0.8										73	3.94	+ 1.0										4.9	
Asheville	2,255	53	75	27.64	29.95	− .04	61.2	− 1.4	83	29	72	31	3	50	37	56	53	81	7.75	+ 4.0	14	5,210	se.	30	nw.	10	10	14	7	5.4	
Charlotte	773	68	76	29.14	29.97	− .02	66.8	− 1.6	89	30	76	42	2	57	29	58	53	66	5.65	+ 1.7	8	4,758	sw.	30	sw.	1	10	14	7	5.4	
Hatteras	11	12	47	29.95	29.96	− .05	68.2	+ 1.1	84	29	74	53	3	62	20	64	61	81	1.42	− 2.7	5	10,968	sw.	47	s.	1	20	7	4	3.7	
Manteo	12	12	46				66.3		85	31	75	41	13	58					6.72	+ 2.6	8		s.				22	4	5		
Raleigh	376	103	110	29.56	29.95	− .04	67.2	− 0.9	88	30	77	43	2	57	29	59	53	65	2.92	− 2.0	11	6,157	sw.	38	sw.	1	11	11	9	4.9	
Wilmington	78	81	91	29.90	29.98	− .03	69.3	+ 0.2	88	18	78	48	2	61	23	62	58	75	3.07	− 1.0	6	6,506	sw.	42	sw.	1	13	13	5	4.2	
Charleston	48	14	92	29.92	29.97	− .04	71.6	− 0.8	90	29	78	52	2	65	19	65	62	76	1.54	− 1.9	5	7,313	s.	39	s.	1	11	14	6	4.7	
Columbia, S. C	351	41	57	29.58	29.96	− .04	69.6	− 2.2	92	29	80	43	2	59	28	61	56	67	4.28	+ 1.1	10	4,765	sw.	30	w.	1	8	18	5	5.2	
Augusta	180	89	97	29.77	29.96	− .03	70.6	− 1.6	93	29	81	45	2	60	30	62	57	65	3.43	+ 0.2	9	4,274	se.	30	w.	1	8	14	9	5.7	
Savannah	65	81	89	29.91	29.98	− .02	71.8	− 0.7	90	29	80	52	2	64	26	65	61	74	4.29	+ 1.3	9	4,938	s.	23	sw.	20	10	15	6	5.0	
Jacksonville	43	96	129	29.93	29.98	− .02	73.8	− 0.4	92	28	82	52	3	66	24	67	65	80	2.26	− 2.0	10	6,284	se.	40	s.	29	9	17	5	4.8	
Florida Peninsula.							77.8	+ 0.8										.78	5.57	+ 2.0										4.4	
Jupiter	28	10	46	29.92	29.95	− .03	77.0	+ 0.6	89	21	82	66	5	72	19	72	70	80	8.61	+ 3.8	16	8,054	se.	36	nw.	20	4	23	4	5.4	
Key West	22	10	53	29.90	29.94	− .03	79.9	+ 0.9	88	31	85	68	8	75	15	75	72	79	6.70	+ 3.3	10	4,800	e.	36	sw.	22	24	6	1	3.1	
Sand Key	25	41	71	29.89	29.92	− .05	79.2		91	24	83	66	8	75	17				4.25	+ 0.9	10	9,201	e.	45	sw.	22	14	15	2	4.1	
Tampa	35	79	96	29.92	29.96	− .03	76.4	+ 0.9	94	29	85	58	3	68	27	69	66	75	2.73	− 0.2	6	5,804	ne.	28	sw.	20	12	11	8	4.9	
East Gulf States.							70.0	− 2.3										74	5.93	+ 2.4										5.3	
Atlanta	1,174	190	216	28.74	29.97	− .02	67.2	− 2.3	86	30	76	39	2	58	26	59	54	68	2.11	− 1.0	13	7,212	se.	38	w.	30	12	7	12	5.3	
Macon	370	78	87	29.57	29.96	− .03	69.8	− 1.3	90	30	80	44	2	60	30				3.54	+ 0.7	14	4,124	s.	26	se.	19	12	11	8	5.1	
Thomasville	273	8	57	29.67	29.96	− .03	73.0	− 1.0	95	31	85	49	4	61	34	64	60	71	2.03	− 2.0	8	3,966	sw.	34	s.	25	17	10	4	3.5	
Pensacola	56	79	96	29.90	29.96	− .03	71.4	− 3.4	84	29	78	50	2	65	24				3.87	+ 1.2	8	7,688	se.	46	w.	19	9	11	11	5.4	
Anniston	741	9	57	29.20	29.98	− .01	67.0	− 1.4	85	30	78	36	2	56	32				4.06	+ 1.0	15	3,868	se.	33	nw.	30	7	12	12	6.4	
Birmingham	700	11	48	29.22	29.97	− .01	68.0	− 3.6	85	28	77	40	2	59	28	62	59	77	4.11	+ 1.0	13	5,147	s.	44	se.	25	6	13	12	5.8	
Mobile	57	98	106	29.89	29.95	− .04	71.4	− 2.2	88	22	79	50	2	64	23	66	63	78	12.10	+ 8.1	12	6,041	se.	34	w.	31	12	13	6	4.9	
Montgomery	223	100	112	29.72	29.97	− .02	70.2	− 3.3	88	30	80	44	2	60	27	63	59	73	4.81	+ 1.0	12	4,725	s.	35	s.	25	13	10	8	5.2	
Meridian	375	84	93	29.54	29.94	− .04	68.4	− 2.7	87	30	79	39	2	58	35	62	58	76	12.15	+ 8.2	13	4,142	se.	34	e.	24	9	11	11	5.5	
Vicksburg	247	62	74	29.66	29.93	− .04	69.8	− 3.1	87	25	79	43	2	61	26	63	60	75	11.82	+ 7.6	12	4,878	se.	52	nw.	25	9	12	10	5.2	
New Orleans	51	90	121	29.88	29.93	− .04	73.9	− 0.6	89	30	82	54	2	66	20	67	64	78	4.61	+ 0.7	13	6,832	se.	30	n.	26	9	11	11	5.6	
West Gulf States.							70.9	− 1.7										74	4.14	0.0										4.7	
Shreveport	249	77	84	29.63	29.90	− .05	71.0	− 2.2	89	30	80	44	1	62	28	64	61	74	5.30	+ 1.1	10	5,462	se.	37	w.	25	14	8	9	4.7	
Bentonville	1303	11	44	28.52	29.88	− .05	63.1	− 3.3	87	5	74	31	1	52	36				7.96	+ 2.7	11	4,537	s.	30	s.	8	16	8	7	4.3	
Fort Smith	457	79	94	29.39	29.87	− .06	67.7	− 2.0	89	5	78	37	2	58	35	59	54	65	7.23	+ 2.3	12	6,260	e.	42	n.	9	16	7	8	4.2	
Little Rock	357	139	147	29.53	29.89	− .05	67.6	− 2.8	85	8	76	40	2	59	30	61	57	72	4.51	− 0.6	11	6,874	s.	48	nw.	9	10	11	10	5.3	
Brownsville	57	4							94	24		61	2						3.11		8										
Corpus Christi	20	69	77	29.82	29.84	− .06	74.7	− 1.8	86	31	79	56	1	71	17	71	69	84	3.68	+ 0.9	9	13,621	se.	49	e.	17	5	16	10	5.7	
Fort Worth	670	106	114	29.17	29.87	− .04	72.6	− 0.6	94	4	84	40	1	61	32				1.09	− 3.1	5	9,383	s.	44	sw.	28	19	11	1	2.8	
Galveston	54	106	112	29.85	29.90	− .04	73.4	− 2.0	85	19	78	54	1	69	16	69	66	80	5.85	+ 2.6	8	9,273	se.	60	sw.	26	15	8	8	4.4	
Palestine	510	73	79	29.35	29.87	− .06	71.2	− 1.3	88	23	81	46	1	61	30	65	62	76	0.98	− 3.9	8	6,133	s.	39	nw.	20	7	13	11	5.8	
San Antonio	701	80	91	29.11	29.82	− .08	75.2	+ 0.4	95	24	86	47	2	65	28	66	61	69	1.77	− 1.2	10	5,540	se.	30	nw.	18	4	24	3	5.3	
Taylor	583	55	63	29.27	29.88	− .03	72.8	− 1.5	90	24	83	47	1	63	30				3.01	− 1.0	10	7,071	s.	38	w.	18	11	17	3	4.2	
Ohio Val. and Tenn.							63.1	− 2.2										69	3.38	+ 0.3										5.5	
Chattanooga	762	106	112	29.17	29.97	− .02	66.8	− 1.8	89	29	77	38	2	57	29	59	54	69	3.62	0.0	18	4,439	sw.	33	se.	24	8	12	11	5.5	
Knoxville	996	93	100	28.90	29.94	− .05	65.9	− 0.6	86	30	76	36	2	56	30	58	54	70	4.14	+ 0.4	15	3,810	sw.	29	sw.	3	9	14	8	5.4	
Memphis	399	76	97	29.52	29.94	− .02	67.0	− 3.7	84	8	75	44	1	59	26	61	57	73	6.26	+ 1.9	11	6,704	s.	56	nw.	9	10	6	15	5.8	
Nashville	546	168	191	29.36	29.94	− .04	66.4	− 2.4	86	29	76	38	2	57	31	60	57	74	4.57	+ 1.1	11	7,625	nw.	46	w.	9	8	12	11	5.7	T.
Lexington	989	75	102	28.89	29.94	− .05	61.8	− 2.5	82	15	71	33	2	53	31				4.15	+ 0.6	14	7,871	ne.	36	w.	1	11	10	10	5.0	T.
Louisville	525	111	132	29.37	29.95	− .03	64.8	− 1.9	87	6	74	37	2	56	30	58	53	70	4.15	+ 0.5	12	6,620	ne.	32	w.	1	9	5	17	6.4	T.
Evansville	431	72	82	29.44	29.90	− .07	64.2	− 2.9	87	29	73	37	2	56	26				2.47	− 1.0	14	6,175	s.	34	s.	15	7	18	6	5.6	T.
Indianapolis	822	154	164	29.05	29.93	− .04	59.8	− 3.5	82	5	68	34	1	51	32	54	50	72	6.01	+ 2.1	14	8,265	ne.	44	w.	2	8	9	14	6.2	T.
Cincinnati	628	152	160	29.26	29.94	− .05	62.2	− 2.9	85	6	71	37	2	53	30	55	50	65	4.21	+ 0.7	14	5,323	ne.	34	w.	2	9	9	13	5.8	T.
Columbus	824	173	222	29.07	29.94	− .04	59.8	− 2.5	84	31	69	33	1	50	31	53	48	68	4.65	+ 0.9	14	9,285	sw.	50	nw.	8	10	9	12	5.7	T.
Pittsburg	842	336	352	29.04	29.94	− .05	60.5	− 2.1	84	15	70	35	2	51	32	52	46	62	1.51	− 1.8	9	7,477	w.	56	w.	2	6	14	11	5.7	T.
Parkersburg	638	77	84	29.30	29.96	− .03	62.4	− 0.9	87	15	73	35	4	52	34	56	51	71	3.10	− 0.4	11	4,391	n.	40	w.	9	17	7	7	4.4	
Elkins	1,940	41	50	27.93	29.96	− .04	58.4	− 0.7	85	15	72	29	4	45	44	51	46	70	2.96	− 1.0	12	3,304	w.	29	w.	2	13	9	9	4.8	0.1
Lower Lake Region.							55.0	− 2.2										73	3.82	+ 0.7										5.6	
Buffalo	767	178	206	29.09	29.92	− .05	53.8	− 0.7	78	31	61	31	2	46	26	50	47	81	4.33	+ 1.2	14	9,961	sw.	60	sw.	2	7	9	15	6.2	5.2
Canton	448	10	71	29.44	29.91		53.3	− 2.9	76	9	62	34	2	44	29				5.27	+ 2.4	17	8,004	sw.	50	sw.	2	6	12	13	6.5	0.1
Oswego	335	76	91	29.55	29.92	− .05	51.8	− 2.9	76	9	60	32	2	44	26	48	44	75	3.21	+ 0.4	14	6,565	w.	30	sw.	2	7	9	15	5.9	T.
Rochester	523	86	102	29.37	29.94	− .03	55.0	− 1.7	81	9	64	32	2	46	32	48	43	68	3.95	+ 1.0	16	6,307	w.	34	w.	2	8	8	15	6.3	3.3
Syracuse	597	97	113	29.28	29.92	− .06	55.2	− 2.1	82	9	64	33	2	46	30				2.84	− 0.6	18	7,843	nw.	46	sw.	2	6	9	16	6.6	T.
Erie	714	92	102	29.16	29.92	− .06	54.7	− 2.6	83	6	62	30	2	47	32	50	45	70	2.36	− 1.1	15	7,545	w.	33	sw.	6	10	11	10	5.4	1.2
Cleveland	762	190	201	29.11	29.93	− .05	55.8	− 2.7	82	6	64	33	2	48	36	50	46	71	2.50	− 0.7	16	9,862	n.	44	sw.	27	9	12	10	5.4	0.4
Sandusky	629	62	70	29.24	29.92	− .06	57.0	− 2.2	83	6	64	33	1	50	33				5.22	+ 2.0	14	6,628	e.	30	w.	2	11	10	10	4.9	T.
Toledo	628	207	246	29.25	29.93	− .04	57.4	− 2.3	83	29	66	31	2	49	35	52	47	72	4.76	+ 1.5	15	11,943	sw.	50	sw.	1	11	15	5	4.4	0.1
Detroit	730	218	258	29.14	29.93	− .04	55.7	− 2.2	81	29	64	30	1	47	34	50	46	74	3.78	+ 0.5	15	11,165	e.	54	w.	1	11	12	8	4.9	0.4

TABLE I.—*Climatological data for U. S. Weather Bureau stations, May, 1909*—Continued.

Stations.	Elevation of instruments.			Pressure, in inches.			Temperature of the air, in degrees Fahrenheit.									Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
	Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Mean max. + mean min. ÷ 2	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Maximum velocity: Miles per hour.	Maximum velocity: Direction.	Maximum velocity: Date.					
Upper Lake Region.							**50.8**	**− 1.4**										**72**	**2.23**	**− 1.1**										**5.7**	
Alpena	609	13	92	29.25	29.92	− .05	50.2	+ 0.7	83	29	59	27	2	41	31	45	40	71	1.83	− 1.5	8	7,826	se.	40	e.	15	10	11	10	5.6	0.8
Escanaba	612	40	82	29.25	29.92	− .05	48.8	− 1.2	77	13	58	23	2	40	32	43	37	68	1.34	− 2.1	5	7,556	ne.	34	e.	15	7	9	15	6.3	T.
Grand Haven	632	54	92	29.22	29.90	− .06	53.0	− 1.8	80	31	62	30	1	44	33	49	45	76	3.17	− 0.2	11	8,896	w.	43	sw.	1	10	11	10	5.4	1.9
Grand Rapids	707	127	162	29.14	29.91	− .06	55.7	− 3.3	82	15	66	28	1	45	36	49	44	68	2.36	− 1.0	11	9,010	e.	44	sw.	1	4	11	16	6.8	0.3
Houghton	668	66	74	29.18	29.90	− .07	47.2	− 2.5	80	29	56	22	1	38	32	...	...	...	2.66	− 0.6	11	5,939	se.	32	se.	6	9	14	8	5.5	2.7
Marquette	734	77	116	29.13	29.94	− .03	46.3	− 2.7	74	29	54	22	1	39	30	41	35	68	1.57	− 1.8	11	6,557	nw.	29	w.	7	12	9	10	4.8	2.9
Port Huron	638	70	120	29.22	29.92	− .05	53.3	− 0.4	80	30	62	31	2	44	33	48	44	75	2.41	− 0.8	11	8,331	ne.	42	sw.	15	6	12	13	6.2	0.1
Sault Sainte Marie	614	40	61	29.23	29.93	− .02	48.6	+ 0.9	79	31	58	23	2	39	33	43	37	68	0.86	− 2.4	9	6,241	w.	35	nw.	10	7	10	14	6.7	0.5
Chicago	823	140	310	29.03	29.92	− .04	55.9	− 0.6	86	5	63	32	1	49	35	51	46	74	2.18	− 1.2	11	11,664	ne.	50	sw.	15	13	11	7	4.8	T.
Milwaukee	681	122	139	29.19	29.92	− .04	52.5	− 1.1	86	5	60	28	1	44	42	47	43	75	2.27	− 1.0	10	7,988	n.	42	sw.	15	14	14	3	3.8	2.1
Greenbay	617	49	86	29.21	29.87	− .08	53.3	− 1.2	80	5	62	28	3	44	37	47	42	70	4.28	+ 0.7	10	8,229	ne.	39	w.	6	7	9	15	6.9	0.5
Duluth	1,133	11	47	28.69	29.91	− .05	44.8	− 3.8	68	29	53	19	1	36	30	42	40	83	1.87	− 1.6	9	11,666	ne.	51	ne.	6	9	11	11	5.9	1.5
North Dakota.							**52.2**	**− 2.0**										**67**	**4.36**	**+ 1.9**										**5.3**	
Moorhead	940	8	57	28.86	29.88	− .06	54.0	− 0.8	83	4	66	21	3	42	51	48	42	71	5.02	+ 2.1	13	7,033	se.	36	se.	11	15	12	4	4.0	1.0
Bismarck	1,674	8	57	28.12	29.89	− .03	52.7	− 2.5	86	4	66	18	1	40	48	46	39	68	4.43	+ 1.9	16	9,209	nw.	46	nw.	5	11	8	12	5.5	0.5
Devils Lake	1,482	11	44	28.31	29.88	− .06	50.6	− 2.1	83	4	62	18	1	40	45	45	38	69	5.18	+ 3.0	15	9,540	e.	42	e.	29	9	11	11	5.5	T.
Williston	1,872	14	56	27.88	29.85	− .08	51.6	− 2.7	86	4	64	20	2	39	47	45	37	60	2.82	+ 0.6	9	8,946	e.	52	nw.	29	7	12	12	6.3	T.
Upper Miss. Valley.							**59.4**	**− 2.5**										**65**	**3.96**	**− 0.2**										**5.3**	
Minneapolis	918	102	208	.....	.....	.....	55.6	.....	88	5	65	24	1	46	37				3.85	− 0.1	12	9,728	se.	50	w.	6	11	9	11	5.5	1.8
St. Paul	837	171	179	28.96	29.86	− .08	55.8	− 2.4	88	5	66	25	1	46	38	48	42	64	3.37	− 0.2	13	8,238	e.	50	nw.	6	7	18	6	5.1	2.0
La Crosse	714	11	48	29.09	29.86	− .08	57.4	− 2.1	91	5	68	28	4	47	42	...	...	...	3.19	− 0.6	10	4,521	se.	24	nw.	15	5	11	15	6.4	0.3
Madison	974	70	78	28.86	29.90	− .06	55.4	− 2.2	86	5	64	28	1	46	40	49	43	66	2.49	− 1.1	12	7,536	se.	34	sw.	15	10	12	9	5.3	0.4
Charles City	1,015	10	49	28.80	29.88	− .06	56.0	− 3.5	91	5	67	26	1	45	49	50	44	68	3.46	− 1.5	13	6,109	e.	30	nw.	6	3	13	15	7.2	0.6
Davenport	606	71	79	29.22	29.88	− .07	59.2	− 3.2	88	5	69	30	1	49	33	52	45	62	3.23	− 1.0	11	6,648	s.	38	ne.	25	10	11	10	5.4	T.
Des Moines	861	84	101	28.95	29.85	− .08	59.2	− 2.4	92	5	69	27	1	49	36	52	46	65	4.24	− 0.3	12	6,875	se.	35	sw.	12	7	8	16	6.3	T.
Dubuque	698	100	115	29.16	29.90	− .05	58.2	− 2.6	90	5	68	30	1	48	39	50	43	61	2.32	− 2.0	10	5,691	s.	30	nw.	6	12	12	7	4.9	0.2
Keokuk	614	64	78	29.21	29.88	− .06	61.0	− 2.2	89	5	71	31	1	50	33	53	47	64	3.03	− 1.2	11	6,163	se.	36	w.	1	17	11	3	3.4	T.
Cairo	356	87	93	29.54	29.92	− .04	65.4	− 2.1	84	5	74	40	2	57	28	58	53	68	3.96	+ 0.1	12	7,265	s.	38	n.	9	9	9	13	5.8	T.
La Salle	536	56	64	29.34	29.91	− .05	58.6	− 2.2	86	5	69	32	1	48	30	...	...	...	3.05	− 0.9	13	7,133	ne.	39	sw.	15	11	11	9	5.1	0.1
Peoria	609	11	45	29.24	29.90	− .06	59.2	− 2.5	86	5	70	32	1	48	35	53	48	68	3.72	− 0.5	14	7,041	s.	38	sw.	15	16	10	5	4.1	T.
Springfield, Ill	644	10	91	29.21	29.89	− .06	61.6	− 1.9	89	5	72	34	2	51	36	54	48	65	5.91	+ 1.4	10	7,144	s.	36	sw.	15	11	10	10	5.2	T.
Hannibal	534	75	109	29.30	29.87	− .07	61.4	− 3.0	90	5	72	32	1	51	39	...	...	...	7.63	+ 2.6	9	7,555	e.	48	sw.	6	13	11	7	4.6	T.
St. Louis	567	208	217	29.28	29.88	− .07	63.5	− 3.0	87	5	72	35	1	55	27	55	49	62	5.99	+ 1.8	9	8,288	se.	36	w.	1	11	11	9	5.3	T.
Missouri Valley.							**59.8**	**− 2.2**										**62**	**4.81**	**+ 0.6**										**5.0**	
Columbia, Mo	784	11	84	29.05	29.87	− .07	61.6	− 2.9	93	5	73	31	1	50	33	...	...	...	6.44	+ 1.6	10	6,449	se.	48	e.	24	16	10	5	3.5	T.
Kansas City	963	161	181	28.82	29.85	− .07	62.9	− 1.6	91	5	72	29	1	54	29	55	48	63	5.77	+ 0.7	11	9,395	s.	35	nw.	6	15	11	5	4.1	T.
Springfield, Mo	1,324	98	104	28.49	29.88	− .05	62.6	− 2.0	88	5	72	30	1	53	32	55	49	65	7.11	+ 1.6	8	8,354	se.	64	s.	14	20	6	5	2.7	
Iola	984	11	50	28.83	29.86	− .06	63.3	− 1.2	90	5	75	29	1	52	35	...	...	...	5.67	+ 0.6	9	6,005	se.	29	ne.	8	10	8	13	5.4	
Topeka	983	85	101	.....	.....	.....	63.2	− 1.8	96	5	74	28	1	53	35				4.93	0.0	10	8,244	s.	39	s.	6	12	12	7	4.8	
Lincoln	1,189	11	84	28.58	29.83	− .08	60.4	− 2.5	97	5	73	25	1	48	48	51	43	61	5.63	+ 1.4	12	8,591	se.	52	nw.	5	5	16	10	5.8	T.
Omaha	1,105	115	121	28.67	29.84	− .08	68.0	− 1.7	95	5	71	25	1	50	44	52	45	63	3.80	− 0.7	10	6,825	se.	38	nw.	6	3	17	11	6.2	
Valentine	2,598	47	54	27.14	29.84	− .06	54.0	− 3.9	90	28	67	17	1	41	53	46	37	62	2.91	− 0.4	14	9,855	nw.	54	nw.	30	14	12	5	4.6	T.
Sioux City	1,135	96	164	28.67	29.87	− .05	58.0	− 2.8	94	5	69	23	1	47	45	...	...	...	3.98	− 0.4	10	10,585	se.	63	nw.	6	5	14	12	6.4	T.
Pierre	1,572	70	75	28.18	29.83	− .08	56.6	− 2.7	87	4	69	20	1	44	47	47	38	56	2.75	+ 0.6	14	9,780	nw.	62	nw.	5	10	13	8	5.0	
Huron	1,306	56	67	28.46	29.85	− .07	55.8	− 1.5	90	5	69	20	1	43	51	48	40	63	3.84	+ 0.9	13	9,692	nw.	46	s.	11	10	13	8	5.1	
Yankton	1,233	49	57	28.52	29.83	− .09	58.1	− 2.0	94	5	70	21	1	46	48	...	...	...	4.93	+ 1.0	13	7,659	e.	48	nw.	6	3	19	9	6.5	
Northern Slope.							**50.0**	**− 3.0**										**61**	**2.33**	**0.0**										**5.7**	
Havre	2,505	11	44	27.24	29.86	− .04	52.8	− 1.3	81	31	64	27	9	41	39	46	40	68	2.98	+ 0.9	11	7,958	nw.	42	sw.	4	15	13	3	4.4	
Miles City	2,371	26	48	27.36	29.90	− .01	55.1	− 1.6	87	4	68	20	1	42	45	48	42	67	2.16	+ 0.2	15	6,422	ne.	41	w.	29	7	17	7	5.2	
Helena	4,110	8	56	25.72	29.90	− .03	48.8	− 2.8	76	21	60	28	8	38	39	41	34	63	2.40	+ 0.4	16	5,900	w.	34	sw.	5	6	15	10	6.2	2.0
Kalispell	2,962	11	34	26.86	29.92	+ .04	48.6	− 2.4	78	3	60	26	1	38	43	41	34	64	1.47	− 0.6	11	4,209	w.	28	sw.	4	7	11	13	5.9	T.
Rapid City	3,234	46	50	26.48	29.88	− .02	51.5	− 2.7	82	4	62	19	1	40	39	44	35	57	5.13	+ 2.2	15	7,219	w.	52	sw.	28	6	17	8	6.1	0.2
Cheyenne	6,088	56	64	23.90	29.85	.00	46.8	− 4.2	75	28	59	18	1	34	43	38	30	60	2.15	+ 0.3	12	9,400	nw.	50	nw.	5	9	15	7	5.7	0.1
Lander	5,372	26	36	24.55	29.88	.00	46.9	− 5.1	73	4	61	19	6	33	45	38	28	53	1.44	− 1.5	10	4,085	nw.	26	nw.	10	9	18	4	5.1	1.5
Sheridan	3,790	9	47	26.00	29.88		48.6	.....	80	4	62	21	1	35	44	41	34	63	3.84	.....	12	7,048	nw.	48	nw.	30	9	9	13	5.7	T.
Yellowstone Park	6,200	11	48	23.79	29.90	− .01	42.3	− 5.1	66	21	54	21	6	31	35	35	27	62	0.95	− 1.0	10	5,792	sw.	36	nw.	5	2	10	19	7.5	4.3
North Platte	2,821	11	51	26.94	29.83	− .05	57.1	− 1.9	92	28	71	19	1	44	50	47	37	57	2.32	− 0.7	12	7,858	nw.	48	nw.	5	11	11	9	5.0	
Middle Slope.							**60.6**	**− 2.4**										**56**	**3.25**	**− 0.6**										**4.7**	
Denver	5,291	129	136	24.62	29.83	− .01	53.3	− 3.4	82	28	66	23	1	40	43	42	31	51	1.74	− 0.8	9	5,780	sw.	37	sw.	28	9	14	8	5.5	T.
Leadville	10,242	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Pueblo	4,685	80	86	25.17	29.81	− .02	56.7	− 2.8	86	28	70	23	1	43	44	44	32	50	1.15	− 0.5	5	5,801	se.	44	w.	28	16	9	6	4.3	
Concordia	1,398	42	50	28.38	29.84	− .07	61.4	− 2.3	97	5	74	24	1	49	44	52	45	60	3.06	− 1.6	9	6,529	nw.	38	nw.	14	8	18	5	5.3	
Dodge City	2,509	44	54	27.25	29.82	− .05	61.4	− 2.1	92	28	76	19	1	47	46	51	42	57	2.53	− 0.8	8	8,720	se.	46	nw.	5	13	14	4	4.1	
Wichita	1,358	98	121	28.45	29.87	− .03	63.7	− 2.2	93	5	75	27	1	52	34	54	46	59	3.64	− 1.3	7	8,667	se.	41	n.	8	12	11	8	4.9	
Oklahoma	1,214	10	47	28.57	29.83	− .06	66.8	− 1.3	90	5	78	33	1	55	36	57	51	62	7.40	+ 1.6	7	11,927	s.	50	s.	14	16	5	10	4.2	
Southern Slope.							**69.3**	**− 1.3**										**47**	**1.14**	**− 1.7**										**3.8**	
Abilene	1,738	45	54	28.04	29.81	− .06	71.4	− 0.5	97	29	84	36	1	59	38	58	48	51	2.71	− 1.0	8	7,074	se.	46	w.	20	8	20	3*	4.6	
Amarillo	3,676	10	49	26.15	29.81	− .03	62.6	− 1.7	93	28	77	27	1	48	45	50	38	52	1.08	− 2.6	8	9,663	s.	52	nw.	8	21	9	1	3.1	
Del Rio	944	8	57	28.85	29.82	− .03	77.8	+ 0.9	102	24	90	48	1	66	37	...	...	...	0.74	− 2.2	7	6,776	e.	31	se.	26	15	14	2	3.7	
Roswell	3,578	9	57	26.23	29.79	− .03	65.4	− 4.0	92	28	83	29	1	48	50	48	32	39	0.05	− 1.1	2	5,677	s.	50	n.	8	13	17	1	3.8	
Southern Plateau.							**62.8**	**− 3.2**										**32**	**0.09**	**− 0.5**										**2.0**	
El Paso	3,762	110	133	26.06	29.74	− .04	69.0	− 3.1	90	27	82	45	1	56	36	46	18	17	T.	− 0.4	0	10,850	w.	50	w.	28	25	6	0	1.7	
Santa Fe	7,013	8	56	23.17	29.76	− .05	51.8	− 4.9	75	28	65	20	1	39	37	39	23	36	0.38	− 0.7	7	7,983	sw.	38	sw.	28	16	14	1	3.5	T.
Flagstaff	6,907	8	57	23.27	29.79	+ .01	47.1	− 3.6	75	31	64	20	1	30	47	34	20	43	0.13	− 0.1	4	7,236	sw.	43	sw.	28	22	6	3	2.6	T.
Phoenix	1,108	50	56	28.64	29.77	− .01	73.0	− 1.8	99	31	88	49	12	58	38	52	30	26	T.	0.0	0	3,626	e.	23	sw.	28	26	5	0	1.2	
Yuma	141	9	58	29.63	29.77	− .02	74.8	− 2.0	106	31	92	51	17	57	44	56	40	37	0.00	0.0	0	5,356	w.	26	nw.	7	31	0	0	0.5	
Brawley	†105	11	31	29.89	29.78	.....	74.4	.....	105	31	92	50	20	57	42	...	...	...	0.00	.....	0	6,473	sw.	38	w.	27	26	4	1	1.6	
Independence	3,910	11	42	25.88	29.82	− .02	60.8	− 3.7	91	31	76	36	11	46	39	45	27	32	T.	− 0.6	0	6,265	nw.	27	w.	21	23	8	0	2.6	
Middle Plateau.							**52.9**	**− 2.7**										**41**	**0.57**	**− 0.6**										**4.0**	
Reno	4,532	56	63	25.42	29.92	+ .01	52.4	− 1.2	85	31	67	27	11	38	41	40	28	46	0.19	− 0.6	6	4,839	w.	32	sw.	15	16	12	3	3.4	
Tonopah	6,090	12	20	23.98	29.78	.....	53.4	+ 1.5	82	31	66	27	11	41	33	39	22	32	0.01	− 1.4	1	7,619	w.	47	nw.	15	12	19	0	3.6	T.
Winnemucca	4,344	18	56	25.56	29.93	+ .02	51.6	− 2.8	84	31	68	20	11	35	50	40	27	47	0.34	− 0.7	4	4,525	sw.	34	sw.	4	16	8	7	3.8	T.
Modena	5,479	10	43	24.51	29.82	.00	51.7	− 2.8	77	31	68	22	1	35	45	38	21	35	0.02	− 1.4	1	9,088	nw.	56	sw.	27	13	17	1	3.8	
Salt Lake City	4,360	105	110	25.52	29.86	.00	53.4	− 4.9	80	4	64	31	1	42	31	43	30	45	2.34	+ 0.4	8	4,906	nw.	36	w.	28	16	11	4	3.9	
Durango	6,546	18	56	23.55	29.79	− .03	49.9	− 5.1	75	27	65	22	1	34	41	37	24	45	0.62	− 0.5	6	5,247	nw.	28	s.	11	7	20	4	4.9	
Grand Junction	4,608	43	51	25.25	29.79	− .04	58.2	− 3.4	83	27	72	29	1	45	38	43	27	36	0.45	− 0.2	5	4,744	nw.	36	s.	28	11	14	6	4.9	
Northern Plateau.							**53.6**	**− 3.2**										**53**	**1.50**	**− 0.2**										**5.5**	
Baker City	3,471	48	58	26.40	29.98	+ .02	48.4	− 2.3	81	31	60	27	8	36	42	42	36	65	1.47	− 0.3	10	5,176	nw.	29	nw.	4	9	15	7	5.1	0.8
Boise	2,739	78	86	27.11	29.96	+ .02	53.6	− 4.0	84	31	66	30	12	41	36	43	31	48	1.00	− 0.3	7	4,600	nw.	27	nw.	5	13	11	7	4.3	T.
Lewiston	757	10	51	29.16	29.97	+ .01	57.8	− 3.0	88	3	69	35	6	46	43	...	...	...	1.32	− 0.3	7	4,227	e.	52	w.	4	6	10	15	6.5	
Pocatello	4,477	46	54	25.39	29.89	.00	50.6	− 4.9	77	3	62	27	13	39	36	41	32	54	2.78	+ 0.6	9	7,125	sw.	53	sw.	5	11	10	10	5.3	T.
Spokane	1,929	101	110	27.91	29.96	.00	53.7	− 2.4	80	3	64	35	5	43	38	44	33	51	1.61	0.0	10	4,923	s.	30	sw.	4	3	8	30	7.3	
Walla Walla	1,000	71	79	28.92	29.99	+ .03	57.8	− 2.9	87	31	69	38	5	47	32	46	34	45	0.80	− 1.0	9	5,033	s.	24	sw.	10	11	16	4	4.5	
N. Pac. Coast Reg.							**50.9**	**− 2.3**										**78**	**2.01**	**− 0.6**										**5.9**	
Blaine	58	4	.....	29.93	29.99	.....	.....	.....	72	3	.....	31	21	.....	.....	.....	.....	.....	1.78	.....	.....	.....	se.	.....	.....	.....	.....	.....	.....	.....	
North Head	211	11	56	29.86	30.10	+ .07	48.3	− 2.9	71	31	52	42	9	45	19	46	44	86	2.45	+ 0.1	19	11,897	nw.	62	se.	30	7	13	11	6.3	

TABLE I.—*Climatological data for U. S. Weather Bureau stations, May, 1909*—Continued.

Stations.	Elevation of instruments.			Pressure, in inches.			Temperature of the air, in degrees Fahrenheit.												Precipitation, in inches.			Wind.									
	Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Total.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
N.P.Coast Reg.-Con.																															
Port Crescent	259	8	53	29.80	30.09	+ .07	46.4	— 2.7	66	31	54	30	20	39	30				1.76	— 0.6	15	3,838	nw.	17	sw.	4	6	21	4	5.5	
Seattle	123	185	224	29.95	30.08	+ .07	52.3	— 2.7	74	2	60	36	5	45	29	47	43	76	1.60	— 0.7	14	6,285	s.	40	sw.	3	5	11	15	6.7	
Tacoma	213	113	120	29.82	30.05	+ .03	52.4	— 2.1	77	2	61	38	5	44	34	47	43	74	2.03	— 0.5	13	4,462	sw.	26	sw.	4	8	10	13	6.0	
Tatoosh Island	86	7	57	29.96	30.06	+ .05	48.2	— 1.4	63	31	52	39	4	44	17	46	43	84	3.29	— 0.8	18	8,366	w.	53	s.	30	4	10	17	7.1	
Portland, Oreg	153	68	106	29.91	30.07	+ .04	54.8	— 2.0	86	2	64	37	21	45	35	48	42	68	1.79	— 0.6	14	4,543	nw.	24	w.	4	8	12	11	5.8	
Roseburg	510	9	57	29.53	30.08	+ .05	53.8	— 2.2	90	2	67	30	5	40	46	46	40	66	1.13	— 0.9	10	2,936	nw.	22	sw.	9	11	15	5	4.2	
Mid. Pac. Coast Reg.							**58.0**	**— 1.5**										**64**	**0.16**	**— 1.0**										**3.1**	
Eureka	62	62	80	30.04	30.10	+ .05	49.6	— 2.5	63	29	54	39	12	45	18	46	44	84	0.76	— 1.8	6	6,418	n.	41	n.	5	13	13	5	4.5	
Mount Tamalpais	2,375	11	18	27.52	29.99	— .01	55.0		82	31	63	36	10	47	26	46	38	57	0.10	— 0.8	3	14,176	nw.	74	nw.	9	24	5	2	2.0	
Point Reyes Light	490	7	18	29.44	29.96		50.0		63	1	54	43	20	46	15				T.		0	22,703	nw.	76	nw.	9	12	12	7	4.8	
Red Bluff	332	50	56	29.57	29.93	— .02	66.5	0.0	98	31	80	45	16	54	37	53	39	43	0.25	— 1.1	4	4,408	nw.	27	ne.	15	25	3	3	1.9	
Sacramento	69	106	117	29.86	29.93	— .01	62.6	— 0.3	94	31	75	44	16	50	32	52	44	58	T.	— 1.0	0	6,693	s.	27	sw.	27	27	3	1	1.7	
San Francisco	155	200	204	29.84	30.01	+ .02	54.5	— 1.0	80	31	61	44	22	48	30	49	45	78	T.	— 0.8	0	8,238	w.	33	sw.	19	17	11	3	3.2	
San José	141	12	110	29.85	30.00		57.0	— 3.7	90	31	70	36	22	44	39				0.00	— 0.7	0	5,027	nw.	24	nw.	10	24	6	1	2.0	
Southeast Farallon	30	9	17	30.00	30.03		50.2		59	1	52	46	13	48	10				0.01	— 0.8	1	14,688	nw.	48	nw.	9	14	11	6	4.4	
S. Pac. Coast Reg.							**60.2**	**— 1.4**										**67**	**T.**	**— 0.6**										**3.9**	
Fresno	330	67	70	29.58	29.93	+ .01	65.6	— 2.8	105	31	82	40	11	49	47	51	37	45	0.00	— 0.6	0	5,472	w.	26	w.	27	30	1	0	0.9	
Los Angeles	338	159	191	29.60	29.96	+ .01	60.3	— 0.2	98	31	68	48	24	53	32	53	49	75	0.00	— 0.5	0	4,557	sw.	20	sw.	28	6	18	7	5.1	
San Diego	87	94	102	29.88	29.97	+ .02	59.8	— 1.0	87	31	64	50	23	56	30	54	50	73	T.	— 0.4	0	4,779	w.	26	nw.	30	10	13	8	5.2	
San Luis Obispo	201	47	54	29.80	30.02	+ .02	55.2	— 1.5	98	31	65	38	12	46	46	49	45	75	0.00	— 0.9	0	4,711	nw.	24	w.	10	11	15	5	4.5	
West Indies.																															
Grand Turk	11	6	20																												
San Juan	82	48	90	29.88	29.97	— .02	79.2		90	24	85	69	2	73	15	73	71	76	2.74	— 1.9	12	8,105	se.	31	se.	23	14	13	4	4.1	
Panama.																															
Christobal	17	5	60	29.84	29.85		79.8		90	21	85	72	18	74	17	75	75	89	7.21		17	4,679	se.	26	se.	25	1	19	11	7.0	
Culebra	172	4	30	29.44	29.85		79.1		91	15	86	68	18	72	22	74	73	92	7.36		22	3,944	nw.	28	ne.	25	0	17	14	7.0	
Ancon	92	6	69	29.75	29.85		79.4		90	31	86	70	18	73	17	75	74	90	9.10		25	4,406	nw.	23	se.	25	0	7	24	8.0	
Alhajuela																			14.32		22										
Bohio																			13.09		21										
Gatun																			8.98		22										

† Below sea level.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for storms in which the rate of fall equaled or exceeded 0.25 in any 5 minutes, or 0.80 inch in 1 hour, during March, 1909, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex	20	D. N.	7:10 a. m.	1.44	5:10 a. m.	5:30 a. m.	0.83	0.06	0.13	0.34	0.53										
Do	24	5:20 a. m.	6:30 a. m.	0.80	5:47 a. m.	6:12 a. m.	0.06	0.46	0.53	0.57	0.66	0.74									
Albany, N. Y	16			0.63														0.32			
Alpena, Mich	23			0.32														0.32			
Amarillo, Tex	19			0.27														0.27			
Anniston, Ala	24-25	5:55 p. m.	D. N.	1.12	9:08 p. m.	9:28 p. m.	0.29	0.05	0.14	0.24	0.44										
Asheville, N. C	9-10	9:25 p. m.	3:00 a. m.	3.28	11:14 p. m.	1:14 a. m.	0.23	0.18	0.38	0.43	0.52	0.56	0.58	0.73	1.01	1.10	1.13	1.16	1.65	2.39	2.70
Atlanta, Ga	30			0.47														0.46			
Atlantic City, N. J	10			0.76														0.61			
Augusta, Ga	20	8:30 a. m.	10:30 a. m.	0.54	8:35 a. m.	8:48 a. m.	0.02	0.14	0.31	0.45											
Baker City, Oreg	27-28			0.77														0.28			
Baltimore, Md	27	7:55 p. m.	9:45 p. m.	1.06	7:57 p. m.	8:14 p. m.	0.01	0.36	0.63	0.80	0.86										
Bentonville, Ark	23-24	9:20 p. m.	3:55 a. m.	1.16	1:23 a. m.	1:38 a. m.	0.23	0.41	0.52	0.58											
Do	24	4:20 p. m.	11:15 p. m.	1.64	7:04 p. m.	7:42 p. m.	0.18	0.10	0.27	0.32	0.35	0.58	1.08	1.26	1.33						
Do	29	8:55 p. m.	11:20 p. m.	1.02	9:39 p. m.	10:13 p. m.	0.02	0.21	0.43	0.64	0.68	0.76	0.83	0.89							
Binghamton, N. Y	10			0.40														0.28			
Birmingham, Ala	30	4:35 p. m.	7:30 p. m.	0.43	4:38 p. m.	4:53 p. m.	0.01	0.12	0.30	0.36											
Bismarck, N. Dak	29			0.77														0.47			
Block Island, R. I	27			0.43														0.29			
Boise, Idaho	27			0.43														0.21			
Boston, Mass	1			1.00														0.58			
Buffalo, N. Y	15	7:28 p. m.	11:58 p. m.	0.72	9:08 p. m.	9:22 p. m.	0.17	0.19	0.29	0.36											
Burlington, Vt	10			1.65														0.52			
Cairo, Ill	6			0.43														0.40			
Canton, N. Y	10			1.22														0.35			
Charles City, Iowa	14			1.29														0.45			
Charleston, S. C	28	12:20 a. m.	3:15 a. m.	0.59	1:11 a. m.	1:27 a. m.	0.01	0.19	0.42	0.50	0.53										
Charlotte, N. C	20	12:40 p. m.	9:15 p. m.	3.06	1:25 p. m.	3:05 p. m.	0.04	0.28	0.40	0.51	0.56	0.62	0.71	0.84	0.99	1.10	1.14	1.35	1.80	2.07	
Chattanooga, Tenn	9			0.70														0.47			
Cheyenne, Wyo	22			0.31														0.26			
Chicago, Ill	25			0.67														0.28			
Cincinnati, Ohio	9			0.90														0.34			
Cleveland, Ohio	27			0.30														0.18			
Columbia, Mo	8			1.68														0.48			
Columbia, S. C	26-27	11:45 p. m.	D. N.	1.06	12:13 a. m.	12:58 a. m.	0.03	0.12	0.31	0.53	0.60	0.64	0.65	0.81	0.92	1.00					
Columbus, Ohio	4			0.66														0.37			
Concord, N. H	16			0.33														0.11			
Concordia, Kans	14	3:30 a. m.	7:35 a. m.	0.49	3:56 a. m.	4:08 a. m.	0.05	0.07	0.39	0.42											
Corpus Christi, Tex	21	5:30 a. m.	10:00 a. m.	1.02	6:55 a. m.	7:12 a. m.	0.13	0.06	0.22	0.53	0.56										
Do	26	7:36 a. m.	10:20 a. m.	1.20	7:54 a. m.	8:35 a. m.	0.09	0.17	0.38	0.46	0.50	0.54	0.77	0.93	1.07	1.10					
Davenport, Iowa	13-14																	0.54			
Del Rio, Tex	18			0.36														0.34			
Denver, Colo	21			0.39														0.25			
Des Moines, Iowa	29	8:45 p. m.	11:20 p. m.	0.68	9:21 p. m.	9:40 p. m.	0.01	0.15	0.28	0.38	0.46										
Detroit, Mich	6	1:14 p. m.	1:28 p. m.	0.33	1:17 p. m.	1:26 p. m.	0.01	0.10	0.32												
Devils Lake, N. Dak	29	3:35 a. m.	9:05 a. m.	2.41	4:29 a. m.	5:24 a. m.	0.48	0.17	0.24	0.31	0.37	0.47	0.53	0.60	0.64	0.66	0.84	0.94			
Dodge City, Kans	24	3:30 p. m.	4:45 p. m.	1.21	3:43 p. m.	4:22 p. m.	0.10	0.37	0.63	0.75	0.85	0.86	0.87	0.96	1.05						
Dubuque, Iowa	14-15	8:40 p. m.	6:35 a. m.	1.24	10:19 p. m.	10:41 p. m.	0.19	0.12	0.16	0.45	0.73	0.78									
Duluth, Minn	15			0.92														0.21			
Durango, Colo	23			0.24																	
Eastport, Me	4			0.50														0.15			

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, etc.*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive began.	Depths of precipitation (in inches) during periods of time indicated. 5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Elkins, W. Va.	8	4:25 p. m.	5:20 p. m.	0.63	4:38 p. m.	4:54 p. m.	0.10	0.11	0.33	0.50	0.52										
El Paso, Tex.	19			T.														T.			
Erie, Pa.	27			0.31														0.26			
Escanaba, Mich.	15			0.99														0.37			
Eureka, Cal.	27			0.28														0.08			
Evansville, Ind.	9			0.86														0.24			
Flagstaff, Ariz.	22			0.08														0.06			
Fort Smith, Ark.	18	8:23 a. m.	12:49 p. m.	1.19	8:32 a. m.	9:10 a. m.	0.01	0.09	0.20	0.35	0.40	0.42	0.49	0.54	0.60						
Do.	29-30	9:58 p. m.	D. N.	1.26	10:30 p. m.	11:00 p. m.	0.03	0.05	0.11	0.21	0.36	0.77	0.99								
Fort Worth, Tex	14			0.45														0.42			
Fresno, Cal	‡																				
Galveston, Tex.	15	7:05 p. m.	11:55 p. m.	1.74	10:52 p. m.	11:27 p. m.	0.39	0.17	0.37	0.67	1.07	1.19	1.24	1.29							
Grand Haven, Mich.	26	4:05 p. m.	5:40 p. m.	0.81	4:32 p. m.	5:02 p. m.	0.03	0.10	0.32	0.47	0.56	0.62	0.67								
Grand Junction, Colo.	28-29			0.24														*			
Grand Rapids, Mich.	31-1	8:12 p. m.	3:15 a. m.	1.33	8:48 p. m.	9:38 p. m.	0.15	0.08	0.13	0.20	0.38	0.47	0.55	0.68	0.74	0.77	0.84				
Green Bay, Wis.	6	6:03 a. m.	9:15 a. m.	0.94	8:27 a. m.	8:51 a. m.	0.24	0.15	0.34	0.40	0.52	0.70									
Greenville, Me.	1			0.41														*			
Hannibal, Mo.	29-30	11:55 p. m.	D. N.	2.04	12:12 a. m.	12:50 a. m.	0.01	0.28	0.52	0.81	1.10	1.15	1.21	1.31	1.47	1.60	1.65				
Harrisburg, Pa.	27			0.85														0.35			
Hartford, Conn.	14			0.17														0.16			
Hatteras, N. C.	28			0.40														0.40			
Havre, Mont.	22			0.63														0.26			
Helena, Mont.	15-16			0.85														*			
Houghton, Mich.	15			1.08														0.31			
Huron, S. Dak.	24			2.02														0.58			
Independence, Cal	7			T.			T.														
Indianapolis, Ind.	6			1.16	6:17 p. m.	6:32 p. m.	0.08	0.15	0.30	0.41											
Iola, Kans.	14	9:12 p. m.	10:30 p. m.	1.28	9:13 p. m.	10:05 p. m.	0.01	0.13	0.18	0.28	0.47	0.56	0.64	0.83	0.99	1.15	1.22	1.27			
Do.	29	6:03 p. m.	7:10 p. m.	1.14	6:05 p. m.	7:01 p. m.	0.01	0.10	0.14	0.42	0.57	0.75	0.81	0.89	0.94	1.00	1.04	1.12			
Jacksonville, Fla.	22			0.53														0.38			
Jupiter, Fla.	8-9	11:00 p. m.	6:15 a. m.	1.22	5:22 a. m.	6:13 a. m.	0.37	0.22	0.24	0.27	0.28	0.29	0.32	0.45	0.51	0.70	0.84				
Do.	18	2:14 p. m.	3:00 p. m.	1.10	2:17 p. m.	2:47 p. m.	0.01	0.11	0.33	0.52	0.68	0.85	1.08								
Do.	20-21	6:32 p. m.	1:10 a. m.	2.16	8:39 p. m.	9:35 p. m.	0.48	0.05	0.29	0.46	0.56	0.57	0.61	0.79	0.98	1.22	1.37	1.58			
Do.	22	8:29 a. m.	2:45 p. m.	0.93	2:26 p. m.	2:39 p. m.	0.31	0.26	0.58	0.62											
Kalispell, Mont.	25-26			0.32														0.17			
Kansas City, Mo.	13	6:10 a. m.	8:45 a. m.	0.87	6:57 a. m.	7:32 a. m.	0.09	0.09	0.24	0.28	0.41	0.46	0.51	0.58							
Do.	14	4:33 p. m.	6:50 p. m.	1.38	5:14 p. m.	6:03 p. m.	0.09	0.07	0.15	0.24	0.46	0.76	0.85	0.96	1.08	1.17	1.25				
Do.	14	7:50 p. m.	D. N.	0.92	7:58 p. m.	8:28 p. m.	0.03	0.07	0.27	0.43	0.47	0.51	0.60								
Keokuk, Iowa	8			0.64														0.21			
Key West, Fla.	8	10:00 a. m.	6:25 p. m.	3.92	11:03 a. m. 4:25 p. m.	12:58 p. m. 4:50 p. m.	0.04 2.84	0.09 0.12	0.20 0.34	0.31 0.54	0.47 0.74	0.62 0.86	0.86	0.89	0.92	0.98	1.00	1.06	1.33	2.13	2.63
Do.	22	5:30 p. m.	9:00 p. m.	0.75	5:39 p. m.	5:53 p. m.	T.	0.15	0.46	0.65											
Knoxville, Tenn.	20	1:50 p. m.	D. N.	1.12	1:59 p. m.	2:39 p. m.	0.02	0.05	0.16	0.29	0.39	0.58	0.67	0.73	0.79						
La Crosse, Wis.	14-15	?	?	1.95	7:56 p. m.	6:05 a. m.	?	0.16	0.31	0.39											
Lander, Wyo.	24			0.94														0.16			
La Salle, Ill.	25			0.98														0.30			
Lewiston, Idaho	27			0.80														0.22			
Lexington, Ky.	9			0.73														0.40			
Lincoln, Nebr.	14	4:15 p. m.	8:55 p. m.	2.50	6:02 p. m.	7:02 p. m.	0.14	0.08	0.20	0.36	0.46	0.70	0.93	1.16	1.38	1.54	1.66	1.84			
Do.	17	4:35 p. m.	8:55 p. m.	0.81	5:42 p. m.	5:55 p. m.	0.28	0.07	0.33	0.47											
Little Rock, Ark.	15	1:20 p. m.	2:15 p. m.	0.36	1:22 p. m.	1:33 p. m.	0.01	0.12	0.31												
Los Angeles, Cal.	‡																				
Louisville, Ky.	25			1.03														0.40			
Lynchburg, Va.	31			0.63														0.56			
Macon, Ga.	30			0.89	8:31 p. m.	8:56 p. m.	0.02	0.12	0.21	0.27	0.33	0.45									
Madison, Wis.	14-15			1.44	11:36 p. m.	11:48 p. m.	0.12	0.19	0.30	0.34											
Marquette, Mich.	15			0.92														0.19			
Memphis, Tenn.	25			0.83	10:19 p. m.	10:39 p. m.	0.01	0.13	0.36	0.52	0.61										
Meridian, Miss.	16	7:03 p. m.	8:45 p. m.	1.11	7:22 p. m.	7:45 p. m.	0.03	0.18	0.41	0.62	0.90	1.03									
Do.	25		6:15 a. m.	4.89	11:44 p. m. 1:30 a. m.	12:14 a. m. 2:27 a. m.	1.38 2.54	0.07 0.16	0.18 0.45	0.45 0.60	0.78 0.68	1.01 0.74	1.09 0.79	0.88	0.99	1.13	1.27	1.36			
Do.	26	1:55 p. m.	3:50 p. m.	1.41	1:57 p. m.	2:45 p. m.	0.01	0.19	0.37	0.41	0.46	0.53	0.85	1.11	1.21	1.25					
Milwaukee, Wis.																					
Minneapolis, Minn.	19			0.98														0.38			
Mobile, Ala.	19	8:44 a. m.	1:25 p. m.	2.91	9:02 a. m.	10:40 p. m.	0.01	0.12	0.20	0.33	0.48	0.55	0.78	1.05	1.21	1.37	1.55	1.63	1.87	2.42	
Do.	24-25	6:20 p. m.	11:00 a. m.	2.73																	
Modena, Utah	27			0.02														0.01			
Montgomery, Ala.	16			0.50	6:12 p. m.	6:27 p. m.	0.01	0.14	0.31	0.37											
Do.	30			0.38	4:17 p. m.	4:26 p. m.	0.01	0.19	0.35												
Moorhead, Minn.	29	4:15 a. m.	6:40 a. m.	0.82	4:25 a. m.	5:05 a. m.	0.03	0.05	0.10	0.15	0.24	0.36	0.49	0.54	0.63						
Do.	29	4:50 p. m.	6:35 p. m.	1.68	5:35 p. m.	6:20 p. m.	0.05	0.05	0.16	0.44	0.75	1.00	1.27	1.38	1.44	1.62					
Mt. Tamalpais, Cal.	27			0.08														0.02			
Mount Weather, Va.	10			0.29														0.29			
Nantucket, Mass.	11			0.88														0.43			
Nashville, Tenn.	9	4:05 p. m.	8:17 p. m.	1.08	4:15 p. m.	4:33 p. m.	0.02	0.12	0.49	0.76	0.83										
Do.	15	5:40 p. m.	8:45 p. m.	1.19	5:46 p. m.	6:36 p. m.	0.02	0.35	0.61	0.62	0.62	0.62	0.70	0.81	0.87	0.96	1.03				
New Haven, Conn.	16			0.39														0.34			
New Orleans, La.	26	4:04 p. m.	6:30 p. m.	2.25	4:04 p. m.	4:55 p. m.	0.00	0.11	0.34	0.64	0.94	1.31	1.60	1.70	1.76	1.82	1.92	1.97			
New York, N. Y.	22			0.67														0.17			
Norfolk, Va.	27			0.62	1:21 a. m.	1:30 a. m.	0.05	0.24	0.34												
Northfield, Vt.	16			0.73														0.22			
North Head, Wash.	26			0.28														0.13			
North Platte, Nebr.	23			1.00	3:29 a. m.	3:42 a. m.	0.09	0.13	0.37	0.42											
Oklahoma, Okla.	8-9	4:40 p. m.	D. N.	3.14	5:06 p. m.	6:31 p. m.	0.13	0.44	0.69	0.74	0.74	0.87	1.18	1.46	1.60	1.70	1.76	1.88	2.24	2.42	
Do.	23	10:12 p. m.	11:40 p. m.	1.65	10:14 p. m.	10:54 p. m.	0.01	0.38	0.71	1.00	1.18	1.31	1.38	1.46	1.51						
Do.	24	3:55 p. m.	5:50 p. m.	1.40	4:00 p. m.	4:40 p. m.	0.01	0.14	0.26	0.53	0.76	0.91	1.07	1.18	1.24						
Omaha, Nebr.	13-14			0.43	12:50 a. m.	1:05 a. m.	0.04	0.12	0.32	0.37											
Do.	29			0.61	6:28 p. m.	6:48 p. m.	T.	0.11	0.25	0.33	0.40										
Oswego, N. Y.	15-16																	0.30			
Palestine, Tex.	20-21	11:20 p. m.	1:45 a. m.	0.65	11:23 p. m.	11:35 p. m.	0.01	0.17	0.35	0.41											
Parkersburg, W. Va.	20			0.86														0.26			
Pensacola, Fla.	24	7:25 p. m.	11:55 p. m.	1.39	10:07 p. m.	10:37 p. m.	0.16	0.12	0.36	0.67	0.92	1.05	1.13								
Do.	25	6:30 a. m.	11:15 a. m.	1.25	9:16 a. m.	9:38 a. m.	0.34	0.22	0.47	0.69	0.75	0.79									
Peoria, Ill.	26	6:05 a. m.	5:15 p. m.	1.46	10:37 a. m.	11:22 a. m.	0.59	0.10	0.21	0.27	0.32	0.41	0.50	0.56	0.66	0.72					
Philadelphia, Pa.	7			0.66														0.36			
Phœnix, Ariz.	13			T.														T.			
Pierre, S. Dak.	29			0.79														0.50			
Pittsburg, Pa.	1			0.32														0.15			
Pocatello, Idaho	16			1.25														0.26			
Point Reyes Light, Cal.	15			T.														T.			
Port Huron, Mich.	15	3:15 p. m.	6:30 p. m.	0.40	4:22 p. m.	4:27 p. m.	0.06	0.26													
Portland, Me.	16			1.10														0.38			
Portland, Oreg.	16			†0.44														0.18			

Table II.—*Accumulated amounts of precipitation for each 5 minutes, etc.*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Providence, R. I.	27			0.35														0.19			
Pueblo, Colo.	21			0.57														0.19			
Raleigh, N. C.	10			0.48	8:31 a. m.	8:42 a. m.	0.07	0.11	0.30	0.33											
Rapid City, S. Dak.	31			0.48	2:05 p. m.	2:16 p. m.	0.04	0.22	0.30	0.33											
Red Bluff, Cal.	21			0.14														*			
Reno, Nev.	23			0.07														0.05			
Richmond, Va.	21			1.23														0.39			
Rochester, N. Y.	15			0.64														0.49			
Roseburg, Oreg.	15			0.42														0.20			
Roswell, N. Mex.	25			0.04														0.04			
Sacramento, Cal.	28			T.														T.			
St. Louis, Mo.	25			1.23														0.50			
St. Paul, Minn.	26			0.71														0.26			
Salt Lake City, Utah	16			0.44														0.27			
San Antonio, Tex.	18			0.59														0.56			
San Diego, Cal.	27			T.														T.			
Sand Key, Fla.	8	8:55 a. m.	7:20 p. m.	2.25	10:30 a. m.	11:20 a. m.	0.11	0.07	0.17	0.29	0.38	0.50	0.59	0.64	0.68	0.71	0.76				
					11:54 a. m.	12:19 p. m.	0.99	0.10	0.30	0.41	0.59	0.67									
Sandusky, Ohio	8	7:26 p. m.	9:15 p. m.	0.63	8:29 p. m.	8:52 p. m.	0.02	0.05	0.16	0.35	0.48	0.55									
Do.	26-27	7:20 p. m.	D. N.	1.32	10:41 p. m.	10:58 p. m.	0.12	0.32	0.44	0.60	0.67										
San Francisco, Cal.	15			T.														T.			
San José, Cal.	‡																				
San Luis Obispo, Cal.	‡																				
Santa Fe, N. Mex.	20			0.24														*			
Sault Ste. Marie, Mich.	15			0.70														0.17			
Savannah, Ga.	1	7:56 a. m.	1:35 p. m.	1.35	10:31 a. m.	11.06 a. m.	0.15	0.05	0.14	0.31	0.57	0.76	0.97	1.03							
Do.	30	1:30 p. m.	5:30 p. m.	1.58	1:36 p. m.	2:16 p. m.	0.02	0.12	0.25	0.59	0.91	1.00	1.11	1.32	1.40						
Scranton, Pa.	7	5:20 p. m.	7:25 p. m.	0.73	6:03 p. m.	6:23 p. m.	0.09	0.11	0.25	0.39	0.55										
Seattle, Wash.	17			0.30														0.17			
Sheridan, Wyo.	23			1.35														0.63			
Shreveport, La.	18	12:45 p. m.	3:10 p. m.	0.98	12:59 p. m.	1:11 p. m.	0.03	0.20	0.56	0.67											
Do.	25	5:40 p. m.	9:00 p. m.	1.00	6:19 p. m.	6:53 p. m.	0.01	0.05	0.13	0.30	0.48	0.73	0.81	0.85							
Sioux City, Iowa	19	4:37 p. m.	6:20 p. m.	0.97	4:48 p. m.	5:16 p. m.	0.02	0.14	0.41	0.63	0.77	0.87	0.89								
Southeast Farallon, Cal.	15			0.01														0.01			
Spokane, Wash.	27			0.72														0.21			
Springfield, Ill.	8			1.15	10:45 a. m.	11:08 a. m.	0.07	0.08	0.29	0.33	0.39	0.49									
Do.	30			0.81	2:51 a. m.	3:08 a. m.	0.01	0.12	0.22	0.54	0.58										
Springfield, Mo.	8-9	4:45 p. m.	D. N.	2.78	6:12 p. m.	6:50 p. m.	0.69	0.07	0.17	0.20	0.23	0.33	0.51	0.62	0.70						
Syracuse, N. Y.	10			0.39														0.22			
Tacoma, Wash.	29			0.41														0.19			
Tampa, Fla.	3	9:07 a. m.	1:50 p. m.	1.31	9:53 a. m.	11:00 a. m.	0.03	0.09	0.16	0.19	0.23	0.28	0.32	0.46	0.57	0.63	0.71	0.85	1.03		
Tatoosh Island, Wash.	29			0.38														0.28			
Taylor, Tex.	6	6:30 p. m.	7:25 p. m.	0.65	6:52 p. m.	7:10 p. m.	0.01	0.26	0.44	0.55	0.62										
Thomasville, Ga.	27	2:48 p. m.	4:20 p. m.	0.83	3:39 p. m.	3:53 p. m.	0.19	0.23	0.33	0.55											
Toledo, Ohio	6	5:44 p. m.	10:15 p. m.	1.26	6:21 p. m.	7:00 p. m.	0.21	0.07	0.14	0.23	0.39	0.55	0.66	0.69	0.76						
Tonopah, Nev.	12			0.01														0.01			
Topeka, Kans.	14	2:45 p. m.	5:30 p. m.	1.72	3:18 p. m.	4:17 p. m.	0.03	0.08	0.17	0.25	0.30	0.33	0.45	0.56	0.99	1.21	1.41	1.61			
Valentine, Nebr.	23			0.85														0.42			
Vicksburg, Miss.	25-26	8:06 p. m.	6:05 a. m.	3.24	11:42 p. m.	12:10 a. m.	0.12	0.46	0.87	1.19	1.40	1.51	1.56								
Do.	31	D. N.	D. N.	1.07	3:09 a. m.	3:25 a. m.	0.07	0.24	0.64	0.82	0.86										
Walla Walla, Wash.	26			0.27														0.09			
Washington, D. C.	27			0.50														0.39			
Wichita, Kans.	13-14			0.95	5:32 p. m.	5:48 p. m.	0.15	0.14	0.28	0.42	0.44										
Williston, N. Dak.	29			1.30														0.34			
Wilmington, N. C.	21			0.91	6:12 a. m.	6:46 a. m.	0.31	0.08	0.20	0.30	0.40	0.46	0.53	0.58							
Winnemucca, Nev.	26			0.10														0.09			
Wytheville, Va.	20			1.92														0.33			
Yankton, S. Dak.	29			0.45	3:51 p. m.	4:05 p. m.	0.01	0.23	0.35	0.42											
Yellowstone Park, Wyo.	23			0.33														*			

* Self register not working. † Estimated. ‡ No excessive precipitation reported during month.

TABLE III.—*Data furnished by the Canadian Meteorological Service, May, 1909.*

Stations.	Pressure.			Temperature.				Precipitation.		
	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean.	Departure from normal.	Mean maximum.	Mean minimum.	Total.	Departure from normal.	Total snowfall.
	Ins.	Ins.	Ins.	°	°	°	°	Ins.	Ins.	Ins.
St. Johns, N. F	29.68	29.82	−.16	42.6	− 0.3	49.6	35.6	5.70	+2.04	.....
Sydney, C. B. I.	29.87	29.91	−.06	45.2	0.0	53.4	37.0	4.22	+0.45	.....
Halifax, N. S	29.82	29.93	−.05	47.9	− 0.5	56.2	39.6	6.30	+2.04	.....
Grand Manan, N. B	29.86	29.91	−.06	49.0	+ 1.1	56.1	42.0	2.09	−1.52	.....
Yarmouth, N. S	29.86	29.93	−.05	47.7	+ 0.1	54.6	40.8	5.06	+1.26	.....
Charlottetown, P. E. I.	29.86	29.90	−.06	46.4	− 0.5	54.5	38.4	3.10	+0.19	.....
Chatham, N. B	29.89	29.91	−.04	48.1	− 0.4	57.5	38.6	2.42	−0.79	.....
Father Point, Que	29.89	29.91	−.02	43.8	− 0.2	51.5	36.0	3.79	+1.21	.....
Quebec, Que	29.59	29.91	−.03	49.4	− 0.5	58.0	40.7	3.92	+0.84	0.3
Montreal, Que	29.68	29.89	−.05	54.0	− 0.7	61.3	46.7	5.93	+2.98	0.1
Rockliffe, Ont	29.30	29.91	−.02	47.6	− 4.7	57.0	38.1	3.04	+0.53	0.1
Ottawa, Ont	29.66	29.98	+.04	52.9	− 2.0	61.9	44.0	5.97	+3.38	.....
Kingston, Ont	29.61	29.92	−.04	52.5	− 0.4	59.4	45.5	4.35	+1.67	.....
Toronto, Ont	29.54	29.92	−.06	53.7	+ 0.5	62.7	44.7	3.82	+0.78	0.8
White River, Ont	28.59	29.91	−.04	44.5	− 1.2	56.6	32.5	1.53	−0.42	12.0
Port Stanley, Ont	29.29	29.93	−.04	52.4	− 0.7	60.9	43.9	5.63	+2.45	0.6
Southampton, Ont	29.22	29.93	−.03	49.6	− 1.1	58.9	40.4	3.22	+0.78	1.5
Parry Sound, Ont	29.23	29.93	−.02	50.2	− 0.9	60.6	39.8	2.68	−0.25	2.0
Port Arthur, Ont	29.22	29.93	−.03	45.4	− 0.5	54.2	36.6	1.20	−0.95	....
Winnipeg, Man	29.10	29.93	−.03	51.8	+ 0.2	64.5	39.2	1.25	−1.03	....
Minnedosa, Man	28.11	29.92	−.04	50.5	+ 2.1	62.8	38.2	1.53	+0.08	0.1
Qu' Appelle, Assin	27.62	29.86	−.08	48.3	− 1.5	60.0	36.7	3.97	+2.32	0.4
Medicine Hat, Alberta	27.59	29.86	−.03	54.3	+ 0.2	65.2	43.3	2.18	+0.87	0.5
Swift Current, Sask	27.34	29.90	−.02	50.8	+ 0.1	62.6	39.0	2.52	+0.76	....
Calgary, Alberta	26.34	29.86	−.02	46.5	− 2.5	57.8	35.2	4.60	+2.83	*
Banff, Alberta	25.32	29.91	+.03	43.4	− 3.6	54.2	32.5	1.49	−0.55	0.6
Edmonton, Alberta	27.59	29.87	−.01	50.5	− 0.3	62.4	38.5	2.96	+1.41	0.8
Prince Albert, Sask	28.33	29.88	−.07	49.5	− 1.9	63.4	35.6	0.58	−0.68	....
Battleford, Sask	28.16	29.89	−.03	51.8	+ 0.8	64.6	38.9	1.49	−0.13	....
Kamloops, B. C	28.62	29.88	−.01	57.4	− 1.7	70.8	43.9	0.73	−0.51	....
Victoria, B. C	29.94	30.04	......	52.2	− 0.3	60.7	43.6	0.96	−0.52	....
Barkerville, B. C	25.60	29.91	+.07	40.8	− 4.7	52.0	29.5	1.62	−0.90	13.2
Hamilton, Bermuda	29.92	30.08	+.02	69.2	− 0.2	73.9	64.6	3.82	−0.84	....
Dawson, Yukon	......	......	......	......	......	......	......	......	......	....

* Report incomplete.

TABLE IV—*Heights of rivers referred to zeros of gages, May, 1909.*

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
	Miles.	Feet.	Feet.		Feet.		Feet.	Feet.
Republican River.								
Clay Center, Kans.	42	18	10.8	18	5.9	13, 14	6.8	4.9
Smoky Hill-Kansas River.								
Abilene, Kans	254	22	14.5	22	0.4	5-7,9,10,12	3.0	14.1
Manhattan, Kans.	160	18	10.0	20, 21	2.9	3-8, 12	4.9	7.1
Topeka, Kans	87	21	12.2	21	6.0	5-8	7.9	6.2
Missouri River.								
Townsend, Mont	2,504	11	8.4	30	5.5	1, 2, 11-13	6.2	2.9
Fort Benton, Mont	2,285	12	7.6	30	2.6	1-4	4.3	5.0
Wolfpoint, Mont	1,952	17	6.3	31	0.5	1	2.6	5.8
Bismarck, N. D	1,309	14	7.9	31	2.1	4, 5	3.6	5.8
Pierre, S. Dak	1,114	14	4.6	31	1.8	1, 2	2.7	2.8
Sioux City, Iowa	784	17	8.9	29-31	5.7	17-19	6.6	3.2
Blair, Nebr	705	15	9.0	27-30	6.3	1-11	7.1	2.7
Omaha, Nebr	669	18	11.5	30, 31	8.8	8, 12-14	9.4	2.7
Plattsmouth, Nebr	641	17	6.0	31	3.4	12	4.1	2.6
St. Joseph, Mo	481	10	6.0	29	2.8	13	3.9	3.2
Kansas City, Mo	388	21	12.2	16, 30	8.7	13, 14	10.3	3.5
Glasgow, Mo	231	21	15.9	18	9.8	15	12.0	6.1
Boonville, Mo	199	20	14.4	18	9.7	15	11.7	4.7
Hermann, Mo	103	24	14.7	13	8.5	8	11.7	6.2
Minnesota River.								
Mankato, Minn	127	18	8.2	2	5.1	15-17,24,25	6.2	3.1
St. Croix River.								
Stillwater, Minn	23	11	9.5	11, 12	7.6	5	8.5	1.9
Illinois River.								
La Salle, Ill	197	18	22.7	2	16.5	25, 26	19.1	6.2
Peoria, Ill	135	14	17.8	5	13.6	31	15.8	4.2
Conemaugh River.								
Johnstown, Pa	64	7	4.6	1	1.6	30, 31	2.5	3.0
Allegheny River.								
Warren, Pa	177	14	12.5	2	1.2	31	3.9	11.3
Parker, Pa	73	20	17.0	1	1.9	27, 28	5.1	15.1
Freeport, Pa	29	20	25.3	1	3.1	27, 28	8.5	22.2
Springdale, Pa	17	27	30.1	1	9.3	27	13.8	20.8
Youghiogheny River.								
Confluence, Pa	59	10	2.8	1	0.5	20, 25-27	1.2	2.3
West Newton, Pa	15	23	5.4	2	0.8	22, 27, 28	1.8	4.6
Monongahela River.								
Fairmont, W. Va	119	25	19.6	2	14.5	20, 26, 27	15.3	5.1
Greensboro, Pa	81	18	13.4	2	7.0	21	8.2	6.4
Lock No. 4, Pa	40	28	17.5	2	8.5	12, 14	10.6	9.0
Muskingum River.								
Zanesville, Ohio	70	25	17.6	3	9.5	20	12.9	8.1
Little Kanawha River.								
Creston, W. Va	38	20	18.3	1	2.2	20	4.1	16.1
New-Great Kanawha River.								
Hinton, W. Va	153	14	7.0	22	2.3	20	4.0	4.7
Charleston, W. Va	58	30	15.8	2	4.7	19	7.6	11.1
Scioto River.								
Columbus, Ohio	110	17	12.5	11	1.5	9, 20	4.8	11.0
Licking River.								
Falmouth, Ky	30	25	24.8	2	2.5	31	7.6	22.3
Kentucky River.								
Beattyville, Ky	254	30	9.5	2	0.4	25	2.1	9.1
Frankfort, Ky	65	31	14.7	3	6.2	20	8.1	8.5
Wabash River.								
Terre Haute, Ind	171	16	15.0	5	3.3	25, 26	9.1	11.7
Mount Carmel, Ill	75	15	13.8	15	6.0	26, 27	10.9	7.8
Cumberland River.								
Burnside, Ky	518	50	24.0	2	2.2	20	7.1	21.8
Celina, Tenn	383	45	23.4	3	4.5	19	9.5	18.9
Carthage, Tenn	308	40	23.6	3	3.8	20	9.5	19.8
Nashville, Tenn	193	40	26.7	5	10.1	20	15.3	16.6
Clarksville, Tenn	126	43	27.5	5	8.7	21	15.9	18.8
Clinch River.								
Speers Ferry, Va	156	20	12.0	1	0.5	31	2.3	11.5
Clinton, Tenn	52	25	21.5	2	4.7	31	8.9	16.8
South Fork, Holston River.								
Bluff City, Tenn	35	12	6.4	1	1.2	31	2.2	5.2
Holston River.								
Rogersville, Tenn	103	14	10.3	1	2.6	20, 31	3.9	7.7
French Broad River.								
Asheville, N. C	144	4	4.5	10, 21	0.5	9	1.8	4.0
Dandridge, Tenn	46	12	11.5	21	2.0	19, 20	3.9	9.5
Tennessee River.								
Knoxville, Tenn	635	12	13.7	2	2.2	20	4.8	11.5
Loudon, Tenn	590	25	16.8	3	1.9	19	5.3	14.9
Kingston, Tenn	556	25	15.3	2	3.4	19	7.0	11.9
Chattanooga, Tenn	452	33	24.8	3	6.1	20	11.7	18.7
Bridgeport, Ala	402	24	18.0	3, 4	4.0	18	9.3	14.0
Guntersville, Ala	349	31	25.8	4	8.3	20	15.1	17.5
Florence, Ala	255	16	14.8	5, 6	4.7	20, 21	9.0	10.1
Riverton, Ala	225	32	30.9	6	14.5	21	21.3	16.4
Johnsonville, Tenn	95	25	22.5	8	8.7	22	14.7	13.8
Ohio River.								
Pittsburg, Pa	966	22	22.2	2	3.2	20	7.9	19.0
Caraopolis, Pa	956	25	22.0	1, 2	4.4	21	9.6	17.6
Beaver Dam, Pa	937	27	32.1	2	5.0	26, 28	11.7	27.1
Wheeling, W. Va	875	36	34.3	2	4.8	29	12.0	29.5
Parkersburg, W. Va	785	36	34.2	3	7.3	31	14.4	26.9
Point Pleasant, W. Va	703	39	40.1	4	8.2	31	17.7	31.9
Huntington, W. Va	660	50	43.8	4	12.4	21	22.3	31.4
Cattletsburg, Ky	651	50	44.8	4	11.9	21, 22	22.6	32.9
Portsmouth, Ohio	612	50	45.3	5	13.1	21	24.4	32.1
Maysville, Ky	559	50	44.3	5	13.4	22	24.8	30.9
Cincinnati, Ohio	499	50	47.0	6	16.0	23	28.2	31.0
Madison, Ind	413	46	38.9	6	14.4	24	24.9	24.5
Louisville, Ky	367	28	20.7	7	7.0	24	11.7	13.7
Evansville, Ind	184	35	35.7	9, 10	13.6	26	25.1	22.1
Mount Vernon, Ind	148	35	34.6	10	13.4	26	24.5	21.2
Paducah, Ky	47	43	34.8	10	18.5	26	27.7	16.3
Cairo, Ill	1	45	42.6	13, 14	29.5	26	37.3	13.1
Neosho River.								
Iola, Kans	262	10	5.9	16	− 1.9	11	0.4	7.8
Oswego, Kans	184	20	9.5	19	0.5	12-14	2.1	9.0
Fort Gibson, Okla	3	22	27.0	26	10.8	6-9	14.0	16.2
Canadian River.								
Calvin, Okla	99	15	11.0	24	1.6	8	2.8	9.4
Black River.								
Blackrock, Ark	67	12	19.2	1	7.4	23, 24	12.8	11.6
White River.								
Calicorock, Ark	272	18	11.1	28	2.5	23	5.2	8.6
Batesville, Ark	217	18	12.9	29	4.5	23, 24	7.0	8.4
Newport, Ark	185	26	19.7	1	8	24	14.8	11.2
Clarendon, Ark	75	30	26.9	7, 8	23.6	29	25.3	3.3
Arkansas River.								
Wichita, Kans	832	10	0.0	23	− 2.4	10-13	−1.7	2.4
Tulsa, Okla	551	16	14.0	26	2.2	7, 8	5.0	11.8
Webbers Falls, Okla	465	23	23.8	27	6.0	7-9	10.3	17.8
Fort Smith, Ark	403	22	26.6	27	4.7	8	10.6	21.9
Dardanelle, Ark	256	21	24.5	28	5.0	9	10.1	19.5
Little Rock, Ark	176	23	23.5	29	4.9	10	9.7	18.6
Pine Bluff, Ark	121	25	27.0	30	9.6	11, 12	13.9	17.4
Yazoo River.								
Greenwood, Miss	175	38	26.5	31	14.3	20-22	20.1	12.2
Yazoo City, Miss	80	25	25.6	28	19.7	24	21.8	5.9
Ouachita River.								
Camden, Ark	304	39	19.5	29	5.2	17	9.8	14.3
Monroe, La	122	40	24.5	3-6	14.8	21, 22	20.1	9.7
Red River.								
Arthur City, Tex	688	27	10.3	29	5.8	10, 16, 17	7.5	4.5
Fulton, Ark	515	28	18.5	30	7.4	15	10.9	11.1
Shreveport, La	327	29	8.0	31	− 0.4	18	2.2	8.4
Alexandria, La	118	36	16.2	31	4.5	25	7.9	11.7

TABLE IV.—*Heights of rivers referred to zeros of gages*—Continued.

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
Mississippi River.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Fort Ripley, Minn.	2,082	10	6.6	16	5.2	2,3	6.0	1.4
St. Paul, Minn.	1,954	14	7.6	8-10	6.7	17,18	7.1	0.9
Red Wing, Minn.	1,914	14	7.3	21,22	5.6	6,7	6.5	1.7
Reeds Landing, Minn.	1,884	12	7.3	21	5.5	31	6.4	1.8
La Crosse, Wis.	1,819	12	8.6	24	7.3	6-8,31	7.9	1.3
Prairie Du Chien, Wis.	1,759	18	10.7	1	9.1	11,12	10.0	1.6
Dubuque, Iowa	1,699	18	12.2	1,2	10.1	13,14	11.1	2.1
Clinton, Iowa	1,629	16	12.5	2	9.4	14	10.6	3.1
Leclaire, Iowa	1,609	10	7.9	2,3	5.5	15	6.4	2.4
Davenport, Iowa	1,593	15	12.1	3	8.8	14,15	9.9	3.3
Muscatine, Iowa	1,562	16	13.8	4	10.3	16	11.6	3.5
Galland, Iowa	1,472	8	7.5	5-7	5.4	16,17	6.2	2.1
Keokuk, Iowa	1,463	15	13.9	6	9.8	16	11.6	4.1
Warsaw, Ill.	1,458	18	16.7	6	12.9	15,16	14.6	3.8
Hannibal, Mo.	1,402	13	15.3	9	11.3	16	13.2	4.0
Grafton, Ill.	1,306	23	19.5	12	15.3	18,19,22-24	16.8	4.2
St. Louis, Mo.	1,264	30	25.1	13	19.3	24	21.2	5.8
Chester, Ill.	1,189	30	21.1	14	16.9	25	18.9	6.2
Cape Girardeau, Mo.	1,128	28	27.8	14,15	21.3	25	23.8	6.5
New Madrid, Mo.	1,003	34	34.5	14,15	24.7	27	30.7	9.8
Memphis, Tenn.	843	33	33.5	17,18	23.9	29	30.4	9.6
Helena, Ark.	767	42	41.9	20	32.2	31	39.1	9.7
Arkansas City, Ark.	635	47	45.2	22,23	41.2	1	43.6	4.0
Greenville, Miss.	595	42	38.9	22,23	34.9	1	37.3	4.0
Vicksburg, Miss.	474	45	43.9	27,28	39.5	1	42.1	4.4
Natchez, Miss.	373	46	45.0	28,29	40.1	1	42.7	4.9
Baton Rouge, La.	240	35	33.4	31	29.9	1,2	32.6	3.5
Donaldsville, La.	188	28	26.3	30,31	23.3	2	24.5	3.0
New Orleans, La.	108	18	16.4	30,31	14.6	6	15.4	1.8
Atchafalaya River.								
Simmesport, La.	127	41	36.8	31	31.8	1-6	34.1	5.0
Melville, La.	103	37	34.2	31	32.3	3-6	32.7	1.9
Morgan City, La.	19	8	4.5	31	2.8	11	3.6	1.7
Hudson River.								
Troy, N. Y.	154	14	8.8	13	5.4	29,30	7.2	3.4
Albany, N. Y.	147	12	8.7	4	2.3	28	6.1	6.4
Delaware River.								
Hancock (E. Branch), N.Y.	287	12	8.1	11	3.4	31	4.8	4.7
Hancock (W.Branch), N.Y.	287	10	6.6	4	3.4	27,31	4.7	3.2
Port Jervis, N. Y.	215	14	8.5	2	2.7	26	5.1	5.8
Phillipsburg, N. J.	146	26	9.8	3	2.5	31	5.2	7.3
Trenton, N. J.	92	18	6.9	3	1.9	31	3.7	5.0
North Branch Susquehanna.								
Binghamton, N. Y.	183	14	8.9	2	2.6	31	4.8	6.3
Wilkesbarre, Pa.	63	17	22.3	2	4.5	30	9.1	17.8
West Branch Susquehanna.								
Williamsport, Pa.	39	20	21.0	1	2.0	27	5.6	19.0
Susquehanna River.								
Harrisburg, Pa.	69	17	16.0	2	2.5	28	5.7	13.5
Shenandoah River.								
Riverton, Va.	58	22	5.6	23	− 0.8	20,21	0.1	6.4
Potomac River.								
Cumberland, Md.	290	8	4.2	28	2.9	12-21	3.4	1.3
Harpers Ferry, W. Va.	172	18	7.5	24	1.0	19-22	2.7	6.5
James River.								
Lynchburg, Va.	230	20	6.8	22	1.9	20	3.4	4.9
Columbia, Va.	167	18	14.5	23	5.6	11	7.7	8.9
Richmond, Va.	111	10	5.7	24	0.7	16	1.7	5.0
Dan River.								
Danville, Va.	55	8	9.3	22	0.3	9,10,19,20	1.3	9.0
Roanoke River.								
Clarksville, Va.	196	12	9.0	23	0.2	20	2.3	8.8
Weldon, N. C.	129	30	34.8	24	10.4	22	16.5	24.4
Tar River.								
Greenville, N. C.	21	22	14.5	6	5.0	22,28	8.6	9.5
Haw River.								
Moncure, N. C.	171	25	18.4	2	6.8	15	9.3	11.6
Cape Fear River.								
Fayetteville, N. C.	112	38	35.3	3	4.0	17	11.9	31.3
Pedee River.								
Cheraw, S. C.	149	27	30.7	23	3.0	19,20	10.8	27.7
Smiths Mills, S. C.	51	16	14.2	31	6.0	21	10.0	8.2
Lynch Creek.								
Effingham, S. C.	35	12	9.6	31	3.8	18,19	5.3	5.8
Black River.								
Kingstree, S. C.	45	12	4.1	26,28-30	0.1	17,18	2.1	4.0
Catawba-Wateree River.								
Mount Holly, N. C.	143	15	9.0	21	2.0	7-9,12-19	3.2	7.0
Catawba, S. C.	107	11	15.7	22	2.6	8,15	5.3	13.1
Catawba-WatereeRiver–Con.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Camden, S. C.	37	24	30.0	23	8.0	13	14.5	22.0
Congaree River.								
Columbia, S. C.	52	15	12.8	2	1.0	16,18	4.1	11.8
Santee River.								
Ferguson, S. C.	82	12	14.7	27	9.8	21	12.3	4.9
Savannah River.								
Calhoun Falls, S. C.	347	15	9.2	2	2.8	17,18	3.9	6.4
Augusta, Ga.	268	32	25.9	2	9.2	20	12.7	16.7
Oconee River.								
Dublin, Ga.	79	30	8.5	5,6	1.7	18	4.6	6.8
Ocmulgee River.								
Macon, Ga.	134	18	11.7	2	4.3	17	6.0	7.4
Abbeville, Ga.	51	11	9.7	2,6	4.0	21	7.1	5.7
Flint River.								
Montezuma, Ga.	152	20	11.9	5	3.9	19	7.2	8.0
Albany, Ga.	90	20	12.7	4	2.6	30,31	5.9	10.1
Bainbridge, Ga.	22	22	13.0	5,6	6.9	20,21,30,31	9.4	6.1
Chattahoochee River.								
Oakdale, Ga.	305	21	22.7	2	7.0	15	9.9	15.7
Westpoint, Ga.	174	20	11.7	3	3.8	16	5.7	7.9
Eufaula, Ala.	90	40	20.0	3	5.5	16	9.6	14.5
Alaga, Ala.	30	25	20.4	4	6.9	17	11.3	13.5
Coosa River.								
Rome, Ga.	266	30	22.6	2	3.4	15	7.1	19.2
Gadsden, Ala.	162	22	18.7	4	5.1	16,20,31	9.0	13.6
Lock No. 4, Ala.	113	17	14.4	3	4.1	16	7.6	10.3
Wetumpka, Ala.	12	45	31.3	2	9.5	16	16.4	21.8
Alabama River.								
Montgomery, Ala.	323	35	29.7	3	7.2	16	14.3	22.5
Selma, Ala.	246	35	34.4	4	9.6	17	18.7	24.8
Black Warrior River.								
Tuscaloosa, Ala.	90	43	35.3	2	8.2	16	14.7	27.1
Tombigbee River.								
Columbus, Miss.	316	33	12.5	31	− 0.5	17	4.5	13.0
Demopolis, Ala.	168	35	51.1	3,4	7.4	17	29.1	43.7
Pascagoula River.								
Merrill, Miss.	78	20	20.1	31	3.2	19	11.0	16.9
Pearl River.								
Columbia, Miss.	110	18	20.0	31	7.1	19	13.4	12.9
Sabine River.								
Logansport, La.	315	25	7.5	1	1.6	19	3.5	5.9
Neches River.								
Beaumont, Tex.	18	10	2.5	31	0.5	1	1.3	2.0
Trinity River.								
Dallas, Tex.	320	25	6.6	19	3.4	14-16,29,30	4.2	3.2
Long Lake, Tex.	211	35	8.6	26	2.5	21,22	4.4	6.1
Liberty, Tex.	20	25	12.3	29	4.6	11,12	6.4	7.7
Brazos River.								
Waco, Tex.	285	24	6.6	18	1.1	17	2.1	5.5
Hempstead, Tex.	140	40	1.1	19	0.0	4,17,18,20	0.4	1.1
Booth, Tex.	61	39	5.8	31	2.1	1	3.2	3.7
Colorado River.								
Austin, Tex.	214	18	7.6	27	1.8	14	3.1	5.8
Columbus, Tex.	98	24	15.3	29	6.0	15	8.0	9.3
Rio Grande River.								
San Marcial, N. Mex.	1,233	14	12.8	10	10.8	5,6	11.9	2.0
El Paso, Tex.	1,030	14	14.4	15	11.9	1,2,8	13.4	2.5
Red River of the North.								
Moorhead, Minn.	284	26	12.5	30	9.5	1,2,5	9.9	3.0
Snake River.								
Lewiston, Idaho	144	24	14.7	29	7.4	2	10.0	7.3
Riparia, Wash.	67	30	14.0	29	8.1	4	10.2	5.9
Columbia River.								
Wenatchee, Wash.	473	40	23.0	31	8.6	1,2	13.1	14.4
Umatilla, Oreg.	270	25	15.9	31	6.9	3,4	9.9	9.0
The Dalles, Oreg.	166	40	24.2	31	10.4	5	14.4	13.8
Willamette River.								
Albany, Oreg.	118	20	4.6	31	2.6	25,26	3.3	2.0
Portland, Oreg.	12	15	12.9	31	6.1	1,2	7.7	6.8
Sacramento River.								
Red Bluff, Cal.	265	23	6.0	5	3.8	26,31	4.7	2.2
Colusa, Cal.	156	28	13.3	6	8.9	27	10.9	4.4
Knights Landing, Cal.	99	18	14.2	1,2,5,11,12	11.6	31	13.1	2.6
Sacramento, Cal.	64	25	20.3	10	17.5	27	19.1	2.8
San Joaquin River.								
Pollasky, Cal.	203	10	5.7	8	3.5	25	4.5	2.2
Firebaugh, Cal.	148	14	10.6	12	8.1	26,27	9.5	2.5
Lathrop, Cal.	49	14	17.2	11	15.3	27,28	16.3	1.9

Honolulu, T. H., latitude 21° 19′ north, longitude 157° 52′ west; barometer above sea, 38 feet; gravity correction, —0.057 inch, applied. May, 1909.

Day.	Pressure, in inches.*		Air temperature, degrees Fahrenheit.				Moisture.				Wind, in miles per hour.				Precipitation, inches.		Clouds.					
							8 a. m.		8 p. m.		8 a. m.		8 p. m.				8 a. m.			8 p. m.		
	8 a. m. *	8 p. m.	8 a. m.	8 p. m.	Maximum.	Minimum.	Wet.	Relative humidity.	Wet.	Relative humidity.	Direction.	Velocity.	Direction.	Velocity.	8 a. m.	8 p. m.	Amount.	Kind.	Direction, from.	Amount.	Kind.	Direction, from.
							°	%	°	%												
1	30.12	30.08	73.0	71.5	78	69	67.0	73	66.0	75	ne.	11	w.	5	T.	0.00	9	S.-cu.	ne.	8	Cu.	ne.
2	30.06	30.06	73.0	69.0	77	67	66.0	69	65.0	81	ne.	15	ne.	15	0.00	T.	3	Cu.	e.	10	Cu.	ne.
3	30.06	30.07	72.0	71.5	77	67	65.7	72	65.5	72	ne.	9	ne.	3	0.01	0.00	9	S.-cu.	e.	7	Cu.	ne.
4	30.06	30.02	74.0	73.0	78	69	66.7	68	67.0	73	e.	4	ne.	10	0.00	T.	6	Cu.	e.	7	Cu.	ne.
5	30.03	30.03	75.0	72.0	79	71	66.0	62	65.0	69	e.	8	e.	12	0.00	0.00	3	Cu.	e.	Few	S.-cu.	0
6	30.05	30.06	75.0	73.0	79	70	66.0	62	66.0	69	ne.	9	e.	3	0.00	0.00	Few Few	Ci. Cu.-n.	w. e.	2	Cu.-n.	0
7	30.10	30.11	72.0	73.0	80	70	67.0	77	67.0	73	e.	9	e.	9	T.	T.	5	A.-cu.	e.	4	Cu.	e.
8	30.13	30.10	76.1	72.0	80	70	66.0	59	66.0	73	ne.	9	ne.	8	0.00	T.	2	Cu.	ne.	0	0	0
9	30.12	30.10	74.8	72.5	80	70	67.2	67	67.0	75	ne.	3	ne.	4	0.00	0.04	6	A.-cu.	e.	4	A.-s.	sw.
10	30.09	30.06	72.8	72.0	78	69	63.5	60	65.5	71	e.	18	ne.	3	T.	0.00	1 6	Ci.-s. Cu.	0 e.	7	A.-s.	0(?)
11	30.06	30.04	74.5	73.0	79	70	66.0	64	66.0	69	ne.	10	e.	3	0.00	0.00	6 1	A.-cu. Cu.	w. e.	0	0	0
12	30.07	30.07	75.0	73.5	79	67	66.0	62	65.0	63	e.	11	e.	12	0.00	0.05	6 2	Ci.-s. Cu.	w. e.	0	0	0
13	30.13	30.12	75.2	73.0	78	67	66.2	62	67.0	73	ne.	11	ne.	22	T.	0.04	1 5	Ci. Cu.	0(?) ne.	5	Cu.	ne.
14	30.13	30.13	75.6	72.0	79	69	65.4	58	65.0	69	e.	10	e.	8	0.03	0.00	2	Cu.	e.	0	0	0
15	30.12	30.10	73.5	72.5	78	70	65.0	63	64.0	63	ne.	12	e.	6	0.00	0.00	5 2	A.-cu. Cu.	sw. e.	3	Cu.-n.	n.
16	30.10	30.08	72.2	72.3	78	69	64.0	64	66.0	72	ne.	14	e.	3	0.00	0.60	8 1	A.-cu. Cu.	sw. e.	4	A.-s.	0(?)
17	30.10	30.07	70.0	72.5	79	68	67.0	77	65.5	69	e.	4	e.	9	0.14	T.	Few 9	A.-cu. S.-cu.	0 e.	0	0	0
18	30.10	30.07	73.0	70.0	79	69	65.0	65	66.0	73	ne.	5	e.	6	0.01	T.	8	S.-cu.	e.	0	0	0
19	30.07	30.06	74.3	73.0	80	70	66.4	66	67.0	73	s.	4	ne.	7	0.00	T.	6 2	A.-cu. Cu.	e. e.	5 3	A.-s. Cu.	0(?) ne.
20	30.09	30.10	74.4	74.5	80	69	67.0	68	66.0	64	ne.	16	e.	14	0.03	0.00	5 2	A.-cu. Cu.-n.	e. e.	0	0	0
21	30.09	30.12	76.0	73.0	80	71	64.5	53	67.0	73	ne.	6	e.	5	0.00	0.00	2 Few	Ci.-s. Cu.	s. e.	0	0	0
22	30.07	30.04	77.0	73.0	80	70	68.0	63	68.0	78	e.	4	ne.	10	0.00	0.00	3 6	A.-cu. S.-cu.	sw. e.	8	A.-s.	nw.
23	30.03	30.00	74.4	74.0	78	68	67.0	68	68.5	76	w.	4	se.	3	0.00	0.00	1	Cu.	e.	9	A.-s.	n.
24	30.02	30.06	74.4	73.0	82	67	67.0	68	66.0	69	w.	6	ne.	2	0.00	0.00	Few	Cu. Lt. haze.	0	4	Cu.	ne.
25	30.10	30.11	75.0	75.0	80	72	66.0	62	68.0	70	ne.	12	ne.	12	0.00	0.00	3	Cu.	e.	4	Cu.	ne.
26	30.14	30.12	75.0	75.0	80	68	67.0	66	67.0	66	ne.	17	ne.	10	T.	0.00	8	Cu.	e.	7	Cu.	ne.
27	30.15	30.14	77.0	74.0	80	68	67.0	59	67.0	69	e.	7	ne.	12	T.	0.00	Few 7	Ci.-s. Cu.	0(?) e.	9	Cu.	ne.
28	30.15	30.10	74.0	74.0	80	69	68.0	74	67.6	69	e.	12	ne.	8	0.04	0.00	6 3	Cu.-s. N.	e. e.	8	Cu.	ne.
29	30.04	30.00	74.1	72.5	80	68	68.0	73	67.0	75	n.	4	ne.	12	0.02	0.00	2 6	A.-cu. S.-cu.	0 e.	10	Cu.	ne.
30	29.99	30.00	74.2	73.5	78	68	63.0	53	69.5	82	sw.	5	e.	3	0.00	T.	6 2	A.-cu. Cu.	ne. e.	10	Cu.	ne.
31	30.04	30.05	77.0	74.0	81	68	68.2	64	67.5	71	n.	2	e.	5	0.00	0.00	1 1	Ci. Cu.	0 0	9	A.-s.	n.
Mean	30.084	30.073	74.3	72.9	79.2	68.9	66.2	65.2	66.5	71.5	ne.	8.7	ne.	7.9	0.28	0.13	5.7	Cu.	e.	4.7	Cu.	ne.

Observations are made at 8 a.m. and 8 p. m., local standard time, which is that of 157° 30′ west, and is 5h and 30m slower than 75th meridian time. *Pressure values are reduced to sea level and standard gravity.

RAINFALL IN JAMAICA.

Through the kindness of Mr. Maxwell Hall, meteorologist to the government of Jamaica and now in charge of the meteorological service of that island, we have received the following data:

The rainfall over the island for the month of May was below the average.

The greatest rainfall, 28.04 inches, was recorded at Troy; and the smallest, 0.62 inch, was recorded at Port Maria.

Comparative table of rainfall.

[Based upon the average stations only.]

MAY, 1909.

Divisions.	Relative area.	Number of stations.	Rainfall.	
			1909.	Average.
Northeastern division	25	17	6.15	11.91
Northern division	22	41	5.75	8.08
West-central division	26	20	11.31	13.37
Southern division	27	26	4.13	7.66
Means	100	....	6.84	10.25

Chart I. Hydrographs for Seven Principal Rivers of the United States, May, 1909.

Chart II. Tracks of Centers of High Areas, May, 1909.

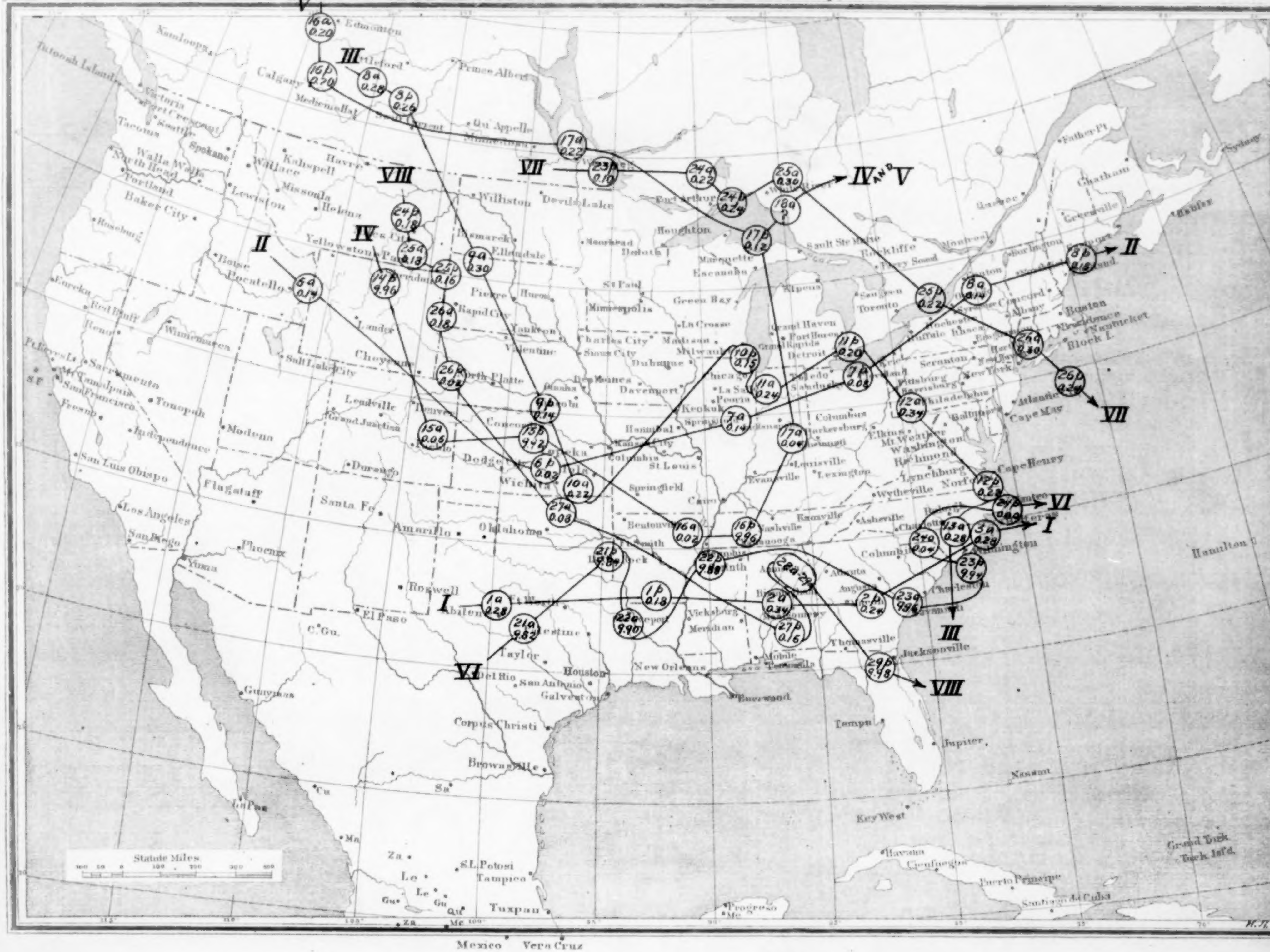

Chart III. Tracks of Centers of Low Areas, May, 1909.

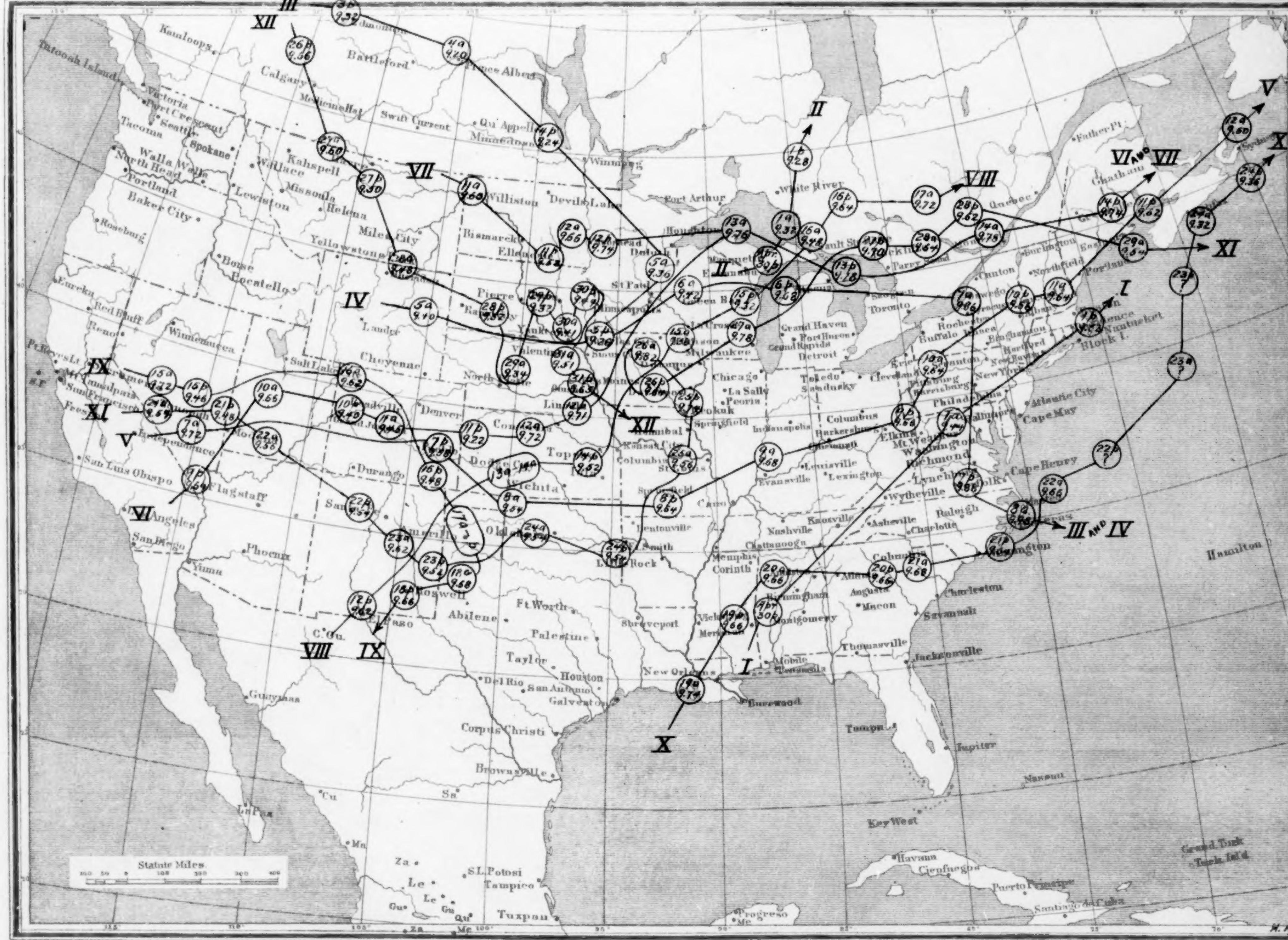

Chart IV. Total Precipitation, May, 1909.

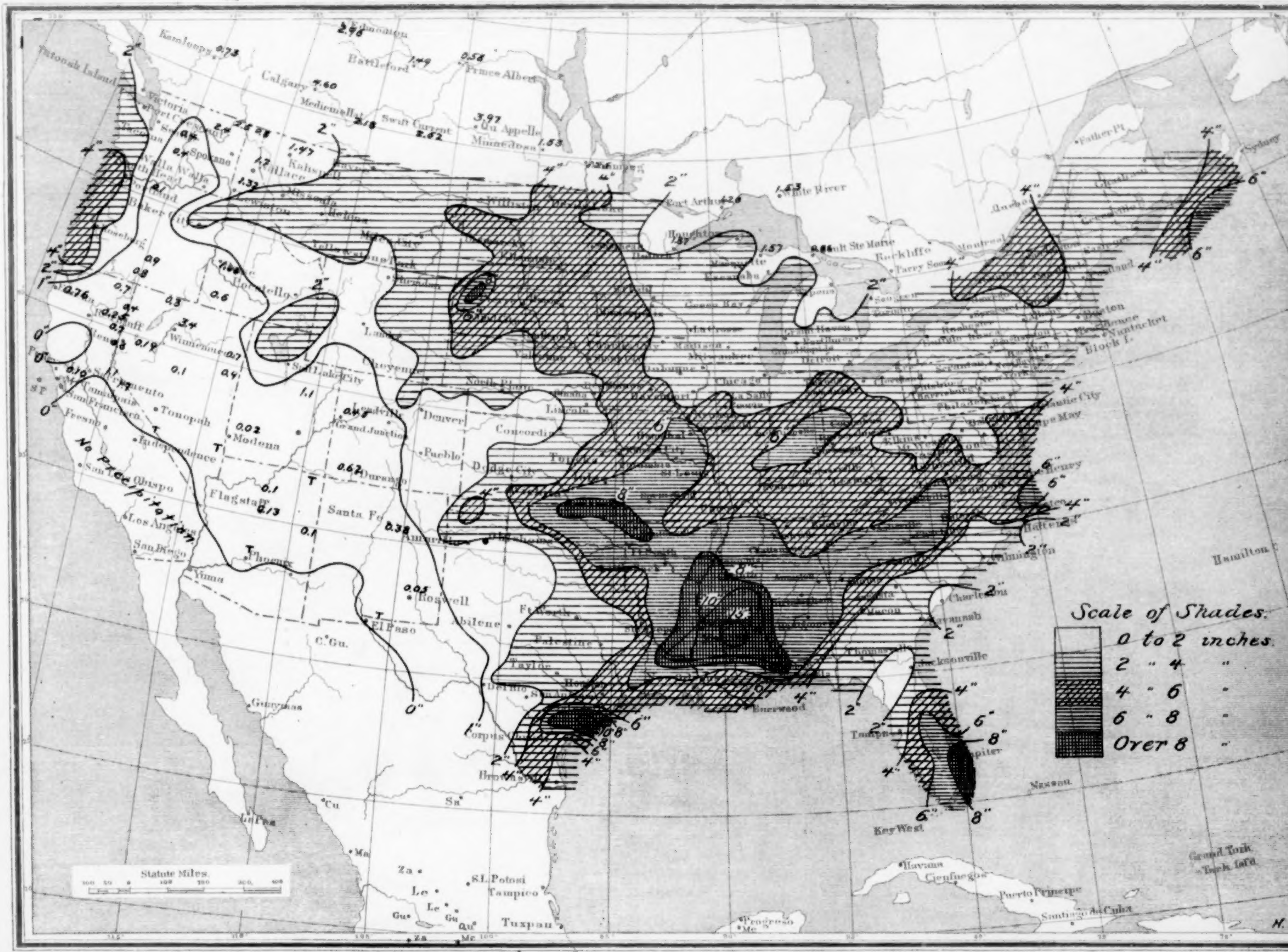

Chart V. Percentage of Clear Sky between Sunrise and Sunset, May, 1909.

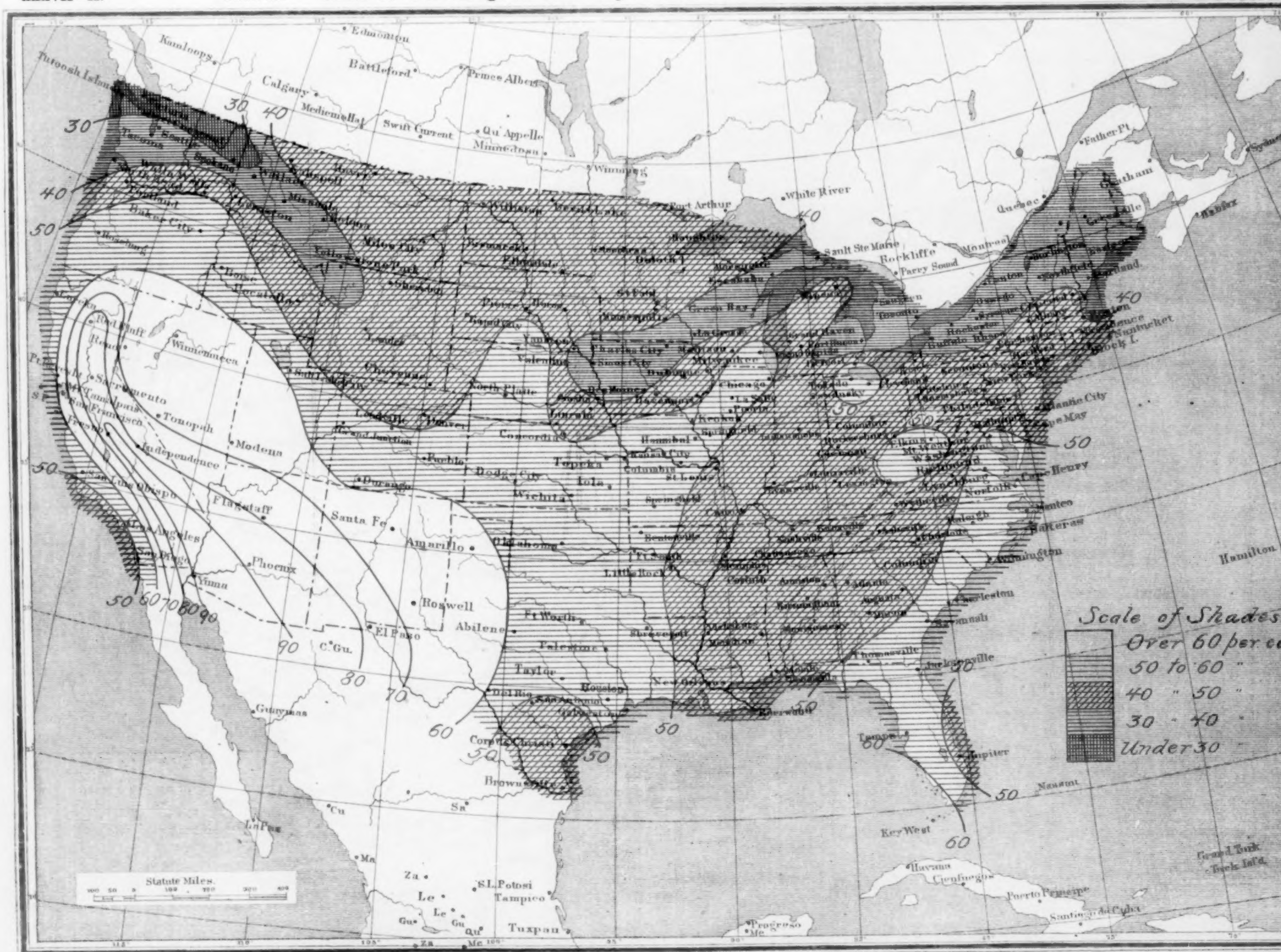

Chart VI. Isobars and Isotherms at Sea Level; Prevailing Winds, May, 1909.

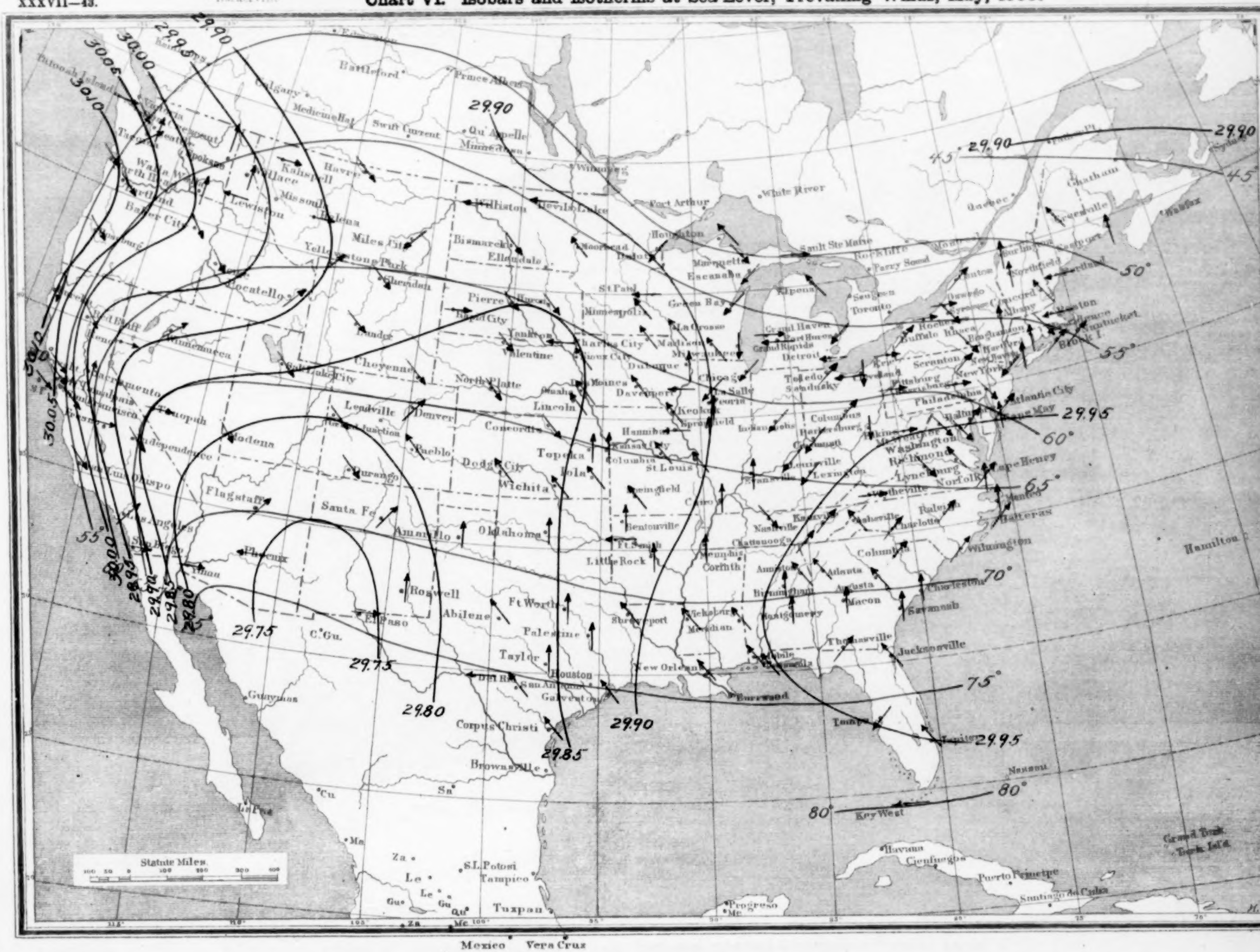

Chart VII. Total Snowfall for May, 1909.